COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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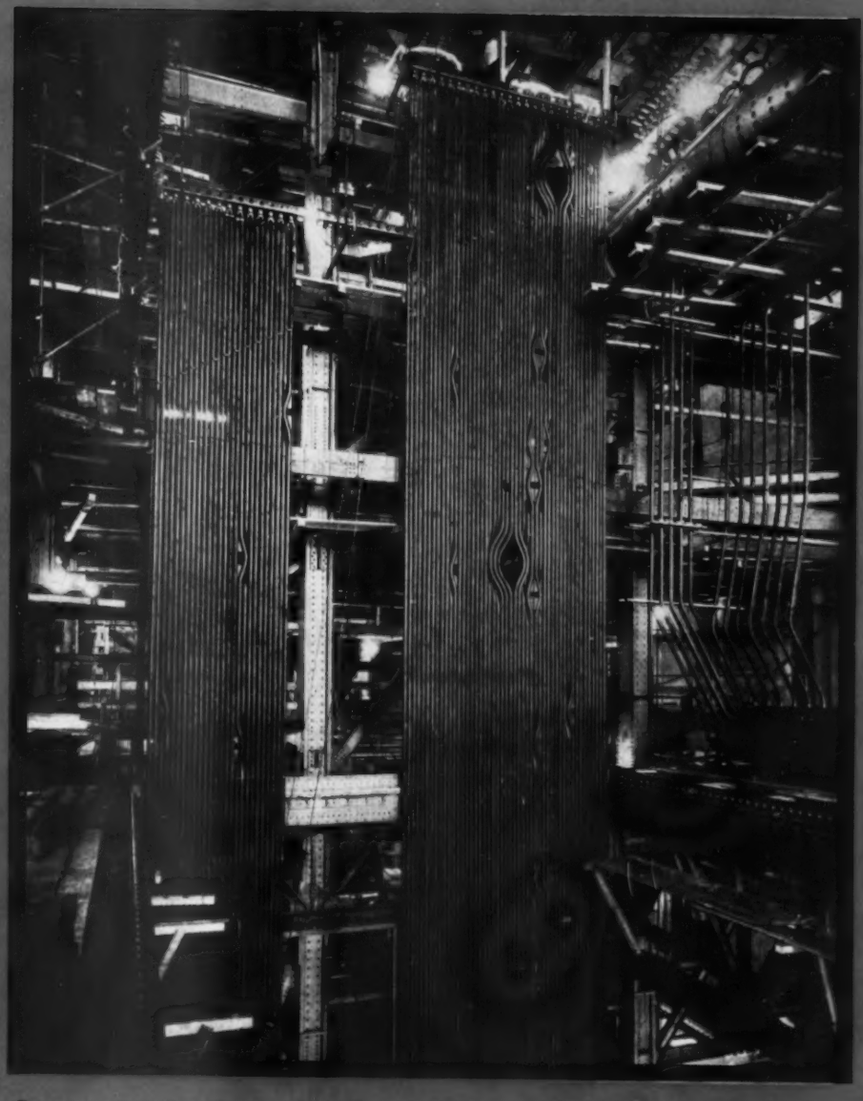
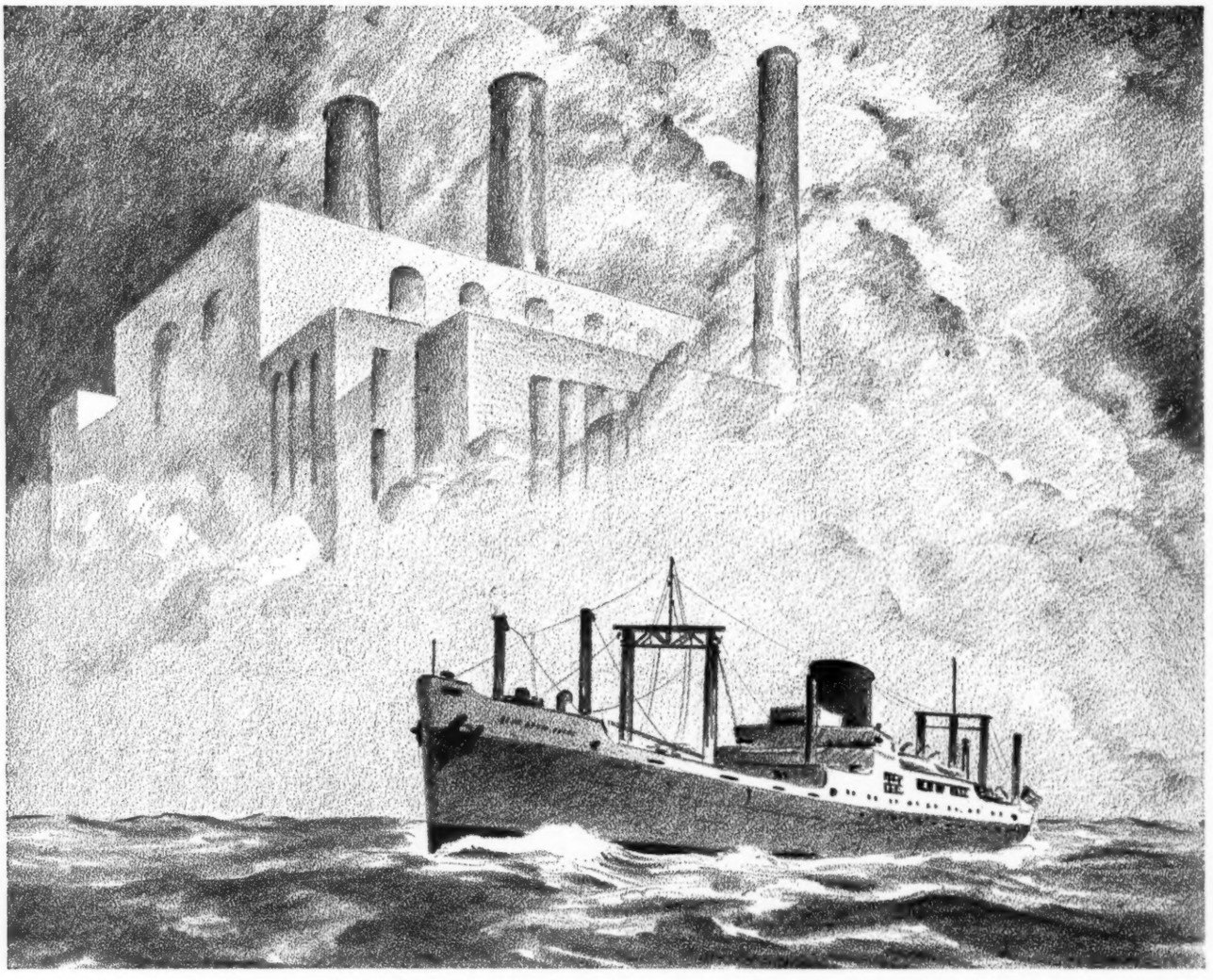


Construction view showing installation of bifurcated waterwall tubes and boiler tubes in 1,000,000 lb per hr boiler unit for large eastern utility

MIDWEST POWER CONFERENCE ▶

Drying Mineral-Wool Insulating Cement on Turbines by Infrared Lamps ▶



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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME FOURTEEN NUMBER TEN

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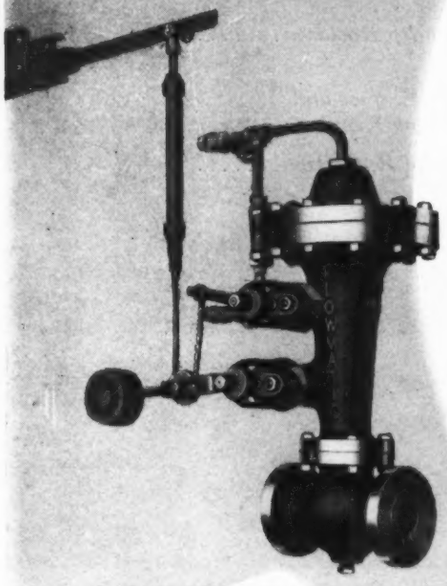

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EDITORIAL

Listing of Used Equipment

The War Production Board is again urging that all idle electric generating equipment and motors, now in the hands of industry, be made available for use by listing with the Used Motor Unit of its Electrical Equipment Branch. This branch has long been rendering useful service in making used equipment available to many applicants for priority ratings.

Response to the earlier appeal resulted in about thirty thousand used generators and motors of all types, characteristics, sizes and conditions being so listed by dealers and industrial plants. Although this number may seem great, the demand continues large in view of the restrictions and high preference rating required for the purchase of new equipment of this kind. Moreover, the available units are widely scattered and it is not always easy to satisfy the particular requirements of a purchaser within a given locality.

There are probably as many more such units, especially motors, in plants throughout the country that have not yet been so listed. Cooperation with the WPB in doing so will go a long way toward assistance in meeting the materials shortage.

Fuel Oil Restrictions Extended to Power Generation

Contrary to some wishful thinking, the approach of warm weather brings no relaxation in regulations affecting the burning of fuel oil in the seventeen eastern states. Instead, further strictures were imposed early this month through an OPA order affecting oil used for power production by both utilities and industrials.

With certain exceptions, whose applicability must be demonstrated, present users of fuel oil are required to convert to coal or to purchase power from hydro or coal-burning stations. The exceptions cover cases where such interconnection is not technically feasible, where it would cause unreasonable interference with plant operation, or where power generation is a by-product of plant operations.

Despite the vast number of conversions that have been made during the last eight or nine months, a major portion of which concerned heating installations, there remain many industrial power installations that have continued to burn oil on the assumption that their war production loads justified their doing so. Apparently the survey undertaken some months ago by representatives of the Petroleum Administrator is now catching up with such cases.

All oil-burning installations are not equally susceptible to conversion to coal. Some of the later units can be very readily changed over to pulverized coal without materially affecting output, whereas others would require additional water-cooled surface if capacity is to be maintained. However, to date the greater number of conversions have been to stoker firing, as this, in general, has involved fewer structural changes and the materials required have been less critical.

Conversions in some cases necessitate compromises over what might have been expected had the installations been laid out from scratch. Nevertheless, makeshifts are seldom justified. With the prospects that these plants will find it necessary to burn coal for a long period and that many may find it advantageous to burn it permanently, quality in both equipment and engineering is warranted. In fact, recent public utterances of representatives of the government indicate that it will be a long, long time before fuel oil returns to its pre-war status.

Rationing cut the use of fuel oil to sixty per cent of normal in the seventeen eastern states during the six months ending March 31. However, military demands continue to increase and tanker sinkings are still a problem. Therefore, the government is apparently determined to attempt to build up depleted stocks before next year's heating season starts.

Engineering Education

In his recent talk before the Midwest Power Conference, P. W. Swain championed practical education as best fitting the individual to meet present and post-war needs, in place of the so-called liberal or cultural education as taught in many schools and universities. His remarks were addressed primarily to engineers and are briefly abstracted in the report of the Conference elsewhere in this issue.

If one were to look back over the last thirty or forty years, he would find first a marked specialization in engineering subjects, carried even to the point of narrowness. This was followed by an era of broadened curricula which, in many cases, involved a combined arts and engineering course of six years. With the advent of war, specialization is again to the front. The extent to which this may prevail in the post-war period will depend upon many factors, difficult to analyze at this time. One of these is the extent to which the Federal Government may enter into the field of higher education, as was recently recommended by the Resources and Planning Board.

Mr. Swain's plea, as we understand it, is to stress fundamentals; discard that which is irrelevant or of a strictly academic nature; incorporate as much practical training as possible in the scholastic course; and include only such cultural subjects as remaining time permits. The objective would be to prepare the student for vocational usefulness and sound citizenship, with an opportunity to broaden his cultural attainments through adult education.

The subject is one of far-reaching importance and Mr. Swain is to be congratulated for having taken a stand that should serve as the basis for constructive discussion.

MIDWEST POWER CONFERENCE

ATTENDANCE at this year's Midwest Power Conference, held at the Palmer House, Chicago, April 8–9, under the sponsorship of the Illinois Institute of Technology, with the cooperation of local sections of the engineering societies and nine midwestern universities, greatly exceeded that of any previous year, and the program of helpful papers measured up to the needs of the times.

At the opening session presided over by **Prof. H. O. Croft, H. B. Gear,** Vice-President of the Commonwealth Edison Company, welcomed those in attendance and the response was made by **Prof. M. P. Cleghorn** of Iowa State College. This was followed by a paper on "Electric Power Supply," by **C. W. Kellogg,** President of the Edison Electric Institute, who reviewed the electric utilities contribution to the war effort.

Reverting to his address of two years ago at which time he predicted the power capacity of the country would prove ample for the defense effort, Mr. Kellogg pointed out that events had proved this correct, despite the fact that the actual subsequent installation of new electric generating capacity in 1941 and 1942 had fallen some two million kilowatts below his previous estimates and war power requirements had vastly increased. During this period the number engaged in war manufacture has increased fivefold and the current government expenditures more than tenfold.

That the need for increased power capacity has not been commensurate with the increased war demand is due to several factors including the substitution of war for peace activities, the extensive pooling of power supply, increased load factor and decreased civilian requirements.

Up to last year the highest annual load factor that had ever been recorded in the public electricity supply was 54.5 per cent, but in 1942 this jumped to 58.4 per cent which, in terms of equivalent generating capacity and energy output, is formidable.

From the viewpoint of generating capacity, the actual output of 1942, if produced at the highest previously known annual load factor, would have required 2,660,000 kw more generating capacity than was in fact needed on peak in that year—an amount nearly half again greater than the entire net growth during 1942 of the combined non-coincident peak loads on all the electric systems contributing to the public supply.

Looked at from the energy viewpoint, the increase in electric energy output, arising solely from higher load factor, and obtained therefore without a single kilowatt of increased demand on generating stations, was 12.7 billion kilowatt-hours; additional energy which would produce nearly two-thirds of our aluminum supply; or an amount of additional energy equal to nearly two-thirds of the entire output of public supply of the Nation in the first year of World War I.

Practical Education Advocated

The final talk at the opening session was by **P. W. Swain,** Editor of *Power*, whose topic was "Practical Education in War Time." With due regard to the desirability of achieving maximum cultivation of mind and spirit, he urged that the former concept of a liberal or cultural education give place to the more practical aspects so that the student would be trained to meet situations that cannot be foreseen in a rapidly evolving civilization. To this end he suggested elementary physics, chemistry, mathematics (mainly arithmetic), practical English, practical economics, typewriting and elementary drawing as definitely of vocational value, with shopwork, biology, advanced sciences and advanced mathematics of value to specific groups. Other subjects, such as geography, history, civics and general economics, may be regarded as cultural and essential to preparation for sound citizenship.

Viewing the object of education as the preparation of the student to live a happy useful life, Mr. Swain believed this could best be achieved by making education primarily vocational, secondarily a training for citizenship and thirdly, cultural to the extent of available time and facilities, and that all three of these may be regarded as cultural.

Boiler Maintenance

"Insistence that production be sustained at all costs is risky business when a plant has reached the point where patches are being patched," said **A. C. Foster** of Foster Wheeler Corporation, in discussing boiler maintenance under wartime conditions. His advice was to strive to eliminate service work through planning and preventive measures.

While little maintenance is usually necessary in completely water-cooled furnaces, those that contain appreciable amounts of exposed refractory may require considerable maintenance, particularly if there is direct impingement of flame. But repairs in such cases cannot be hurried as adequate time must be allowed for refractory materials to set.

A carefully made temperature and gas analysis traverse will show up leaky baffles, setting leaks, poor burner operation and fouled surfaces. It will be found worth while to check the draft loss, not only across the boiler but also across the individual passes, for it is quite possible that high furnace maintenance, caused by lack of fan capacity, may be cut down materially by reducing the draft loss.

Of all the boiler repairs likely to be neglected, those to baffles probably head the list. Leaky baffles increase fuel consumption and reduce maximum output, and if high gas velocities occur at the leaks, the fly ash passing through may tend to cut the tubes.

The drop in CO_2 between the boiler entrance and exit should be measured to ascertain the amount of air infiltration. A reduction in setting leakage will reduce furnace maintenance by permitting operation with lower CO_2 leaving the furnace for a given CO_2 leaving the boiler.

At all inspections, the steam drum internals should be checked carefully, also the continuous blowoff piping to make sure that it is located below the normal water

line and the chemical feed lines to make sure that they are free, since they plug easily.

With reference to superheaters, it is important to determine the pressure drop and compare it with the guarantee. This will indicate whether there is internal fouling, due to operation with too high boiler-water concentrations, too high a water level in the drum, foaming or priming, or leakage past the steam washer and drier. Such deposits are usually water-soluble and may be removed by flushing with warm water. When the deposits are not soluble in water, good results may be obtained by boiling out the superheater with a 5 per cent solution of lactic acid. The elements are filled with the solution and the unit fired at a moderate rate to maintain a temperature in the superheater of about 200 F for ten or twelve hours.

More superheaters are damaged while the unit is being placed in operation, when little or no steam is flowing, than at any other time. It is just as important to protect the superheater by having steam flow through it when it is exposed to radiant heat or hot gases as it is to have water in the boiler when it is fired. It is important that the heat be uniformly distributed over the superheater surface during the warming up period, particularly with superheaters of the non-drainable type.

Economizer maintenance usually consists of cleaning the internal and external surfaces and reducing air leakage to a minimum. However, with economizers having low inlet-water temperature, below 210 F, oxygen corrosion may be the cause of considerable maintenance.

Removal of External Economizer Deposits

External corrosion and fouling are generally caused by operating with too low tube metal temperature, the controlling factors being the incoming feedwater temperature, the excess air and the sulphur in the fuel. In general, external deposits may be removed by soaking with water at 150 to 180 F for ten to twelve hours, and when the construction does not incorporate a hopper directly below the economizer, or where the spray water will run down the gas ducts, a temporary drainable trough may be built.

Air heater maintenance usually consists of cleaning and reducing air leakage; little maintenance is required normally for forced-draft fans, other than bearings; whereas induced-draft fan maintenance will depend upon the fly ash that must be handled with the gases. Such maintenance is likely to be high if the fly ash is not collected ahead of the fan. Also, the higher the speed, the greater the wear.

Poor burner performance, excessive slagging, high combustible loss and high furnace maintenance, all of which may reduce maximum output, may be due to coarse grinding; hence, the importance of pulverizer maintenance.

Burners are another part of the installation that are apt to be neglected. The throats and nozzles should be kept in good repair. Poor flame travel and lack of adequate mixing of the coal and air may result from overextending the life of the coal nozzles. Where ignition has been maintained too close to the burner, the nozzle may grow to such an extent that the velocity of the leaving mixture is too low and it then becomes impossible to control the flame shape and travel.

Effect of Coal Sizing

"The Effect of Coal Sizing on Efficiency and Operation of Mechanical Stokers" was the subject of a paper by **Otto de Lorenzi,** Asst. Gen. Sales Engr. of Combustion Engineering Company.

Because of lack of uniformity in designation of coal sizing in different localities, it has been necessary for manufacturers of coal-burning equipment to set up specifications that have general application to all areas. Those most frequently used for bituminous coals are:

(*a*) $^3/_4$-in. nut and slack ($^3/_4$ in. × 0 in.).
(*b*) $1^1/_2$-in. nut and slack ($1^1/_2$ in. × 0 in.).
(*c*) 2-in. nut and slack (2 in. × 0 in.).

The foregoing does not insure that the coal, regardless of origin, will be uniform in size, but simply indicates the screens through which it is prepared. The actual percentage of nut and slack, or size distribution, will depend on the friability or relative hardness. Stoker mechanism must be changed for size variations if consistently good operating results are to be maintained.

Coals that have strongly caking or coking characteristics perform better when the percentage of lump is relatively high. The slack frequently will coalesce or swell, which action may blanket the fuel bed, whereas the lump tends to keep the fuel bed ventilated. Agitation, by movement of the grate surface, will also assist in breaking up the masses of caked or coked coal.

On a multiple-retort stoker, the coarser coal finds its way to the tuyères near the front and the fines travel the length of the retort. As there is no lateral motion to feed the coal directly onto the tuyères there is a high ridge of ignited and smoldering coal over each retort and high combustion rates and thin fuel beds exist over the tuyères. To shake down and level out these alternately thick and thin ribbons is the function of the reciprocating overfeed section. By control of this action and the admission of correct air quantities, the fuel bed may be burned out uniformly across the width of the stoker. Best results are obtained when there is a uniform gradation from lump to slack, as excessive fines make it necessary that the greater part of the burning be carried out on the overfeed section which means localized high combustion rates and resulting increased carbon loss.

With spreader stokers, the fines are burned in suspension and the larger particles on the grate. While this type of stoker will handle coal up to $1^1/_2$ in. × 0 in., the recommended sizing is $^3/_4$ in. × 0 in. However, "bug dust" and similar sizes can be handled satisfactorily. All coals from semi-anthracite to lignite can be handled with facility and anthracite has also been burned, but its size range is usually confined to a narrow band that makes uniform distribution uncertain and difficult to maintain. Caking and coking qualities have little effect on performance, but consideration must always be given to the use of a dust collector with this type of stoker.

Coal sizing plays an important part in the performance of traveling grate stokers, probably more so than with other types because the fuel bed should be thin and possess relatively uniform resistance to air flow if operating difficulties are to be avoided.

Free-burning bituminous coals are most suitable for traveling grate operation, although by specifying a small range in volatile matter and employing double-screened

coal, it has been possible to burn successfully eastern bituminous coals having strong coking characteristics.

In some cases, size specifications must be forgotten in the interest of producing low cost steam, as, for instance, when washery "slurry" containing up to 18 per cent moisture, 30 per cent ash and 10 per cent sulphur is burned on traveling grate stokers. In some such cases the water actually runs out of the wind boxes, yet it is possible to develop a capacity of 1500 boiler horsepower with a grate area of 160 sq ft.

Anthracite is the fuel on which there is perhaps the greatest amount of data covering the effect of sizing and the Coxe stoker is synonymous with the efficient burning of small sizes of anthracite such as No. 3 buckwheat, barley, No. 4 buckwheat, river coal, culm, silt, etc.

Mr. de Lorenzi included the results of tests with various sizing on different types of stokers and concluded his talk with colored moving pictures showing stoker operation and fuel bed conditions.

Bottlenecks in Piping Materials

G. W. Hauck, of the Crane Company, pointed out how it is possible to break bottlenecks in the supply of piping materials by using cast-iron flanges, malleable fittings, screwed fittings, etc., wherever possible in place of steel.

With the advent of higher pressures and temperatures there had been an increase in the use of steel for piping materials. Concurrently, there developed a preference for steel instead of cast iron to take advantage of its greater strength even in those services where basic requirements of elevated operating conditions did not necessitate the use of steel. Hence, steel flanges on most lines comprising piping systems became accepted practice. Also, when welding came into wide use for pipe joints it gave impetus to the swing from iron to steel.

With steel now in unprecedented demand for war materials there isn't enough to go around and flanges do not escape the critical shortages. This has brought about a bottleneck in their supply and made it necessary to revert to cast iron except for such service conditions as make steel mandatory. Cast-iron screwed flanges and cast-iron lap joints (Van Stone) flanges may be used for service where the saturated steam pressure does not exceed 250 psi and the temperatures do not exceed 450 F. They are available in a wide range of sizes, in 125-lb and 250-lb pressure classes. Care must be exercised, however, in bolting up any lap joints having cast-iron flanges in order to prevent breakage through applying too heavy bolt loads. Moreover, they should not be used on the ends of an expansion pipe bend and are not recommended for lines handling hazardous fluids, or where fire hazard legislates against their use.

There is also a shortage of steel unions which can be relieved by employing malleable iron unions where operating conditions permit.

The same applies to the use of cast-iron and malleable iron screwed fittings of small size.

Costly delays often result through a purchaser insisting on special valve-stem packings and special operating devices for valves, and under present conditions these should give way to manually operated valves wherever practicable.

Automatic Control to Increase Plant Capacity

This subject was discussed in a paper by **H. H. Gorrie** of the Bailey Meter Company, who pointed out that present conditions require the power engineer to meet unprecedented power demands with existing equipment, often a limitation on fuel or transportation facilities and a deficiency of trained personnel. Translated into operating requirements, this means that careful consideration must be given to ways and means of obtaining:

1. Maximum fuel economy.
2. Simplified operation and more efficient use of personnel.
3. Increased life of boiler, furnace and auxiliaries.
4. Improved prime mover efficiency.
5. Maximum boiler output.
6. Protection against accidents and costly shutdowns.

To this end guesswork can be eliminated only through the use of instruments to tell the many important things taking place within the pressure and combustion systems; and the information thus obtained must form the basis for establishing an operating plan. The use of automatic control equipment will insure that the plan of operation is diligently followed under all load conditions.

It is not easy for an operator to acquire the knowledge of boiler operation necessary for critical observation of overall boiler performance which will enable him to analyze trouble symptoms and make corrections before emergency shutdowns occur, but a boiler equipped with a full complement of instruments and controls will speed this process. Moreover, the life of a boiler and furnace is closely related to the proper control of fuel and air to prevent excessive furnace temperatures, extreme variations in draft, slagging of tubes, excessive superheat and excessive variations in drum water level.

Turbine-Blade Deposits

Prof. F. G. Straub reviewed some of the results of earlier investigations of turbine-blade deposits and explained the several theories that have been advanced to account for this phenomena. These are the "carry-over," "evaporation," "solubility," "caustic" and "molten-salt" theories. The limitations and applicability of each were discussed and the following conclusions were offered:

1. Insoluble silica deposits form in the temperature range between 400 and 550 F.
2. The amount of silica deposits is not directly related to the soluble silica content of the boiler water.
3. It is possible that a proper balance of the chemicals in the boiler water might reduce the silica deposits in the turbine.

Conversion from Oil to Coal

Samuel I. Rottmayer, mechanical engineer of Chicago, after listing the difficulties often encountered in converting small heating plants from oil to coal, discussed the situation with reference to medium and large size steam generating equipment. In such cases the

finding of space to meet coal burning requirements had presented more of a problem than in smaller plants, for in the original layout of many of the larger plants, floor area had represented intrinsic investment value, especially in metropolitan areas. Not only is it frequently difficult to find sufficient space for coal storage and handling, and for ash removal and disposal, but adequate combustion space for coal firing has often necessitated excavations below the boiler room floor, also, refractory furnaces in many cases required water cooling. Such alterations frequently entail large expense.

The author included a number of case histories to illustrate these points.

Engineering Economics of Product Design

Ronald B. Smith, of the Elliott Company, presented a paper dealing with the economic aspects of product design.

Management usually insists upon an overall economic appraisal of the worth of a new project but such an appraisal seldom brings to light the contribution of an individual machine to the economic worth of the project as a whole. Consequently, the apparatus designer may fail to grasp the economic aspects of its operation and concentrate his efforts on a reduction in the first cost. On the other hand, the purchaser and his technicians are resigned to the acceptance of operating performance on well-developed equipment at competitive levels. They are seldom sufficiently specialized to recognize the possibilities of further improvements and to appraise the cost of bringing them forth.

Both first cost and operating cost enter an economic study. For power equipment, where operating costs far outweigh first cost, research directed at the operating aspects can frequently yield a realistic gain. As an example, power generation by means of a steam turbine was taken and it was shown that, under given circumstances, a 15 per cent improvement in prime mover efficiency could justify a 100 per cent increase in the first cost of the machine, or that a 15 per cent failure to meet performance would justify rejection of the equipment even as a gift.

Efficiencies of single-stage centrifugal blowers were also discussed and, while the incentive for the risk of capital to develop more efficient centrifugal blowers is considerably less than for turbines, there are indications that the results may be more easily attained.

Comparison between the efficiency of modern centrifugal pumps and blowers was also given. It was shown that the only commonly recognized loss which is not a unique function of the specific speed for two geometrically similar rotors, one for air and one for water, is that represented by the mechanical efficiency. Although a full explanation is not yet possible, experimental evidence indicates that the discrepancy in performance between hydraulic and air practice is, in part, due to contact losses within the impeller.

Power, Heating and Lighting Services at Army Cantonments

At a special session on Friday evening, designated as "Army Engineering Hour," the heating, power and lighting for Army camps were discussed. The first paper, by **Lt. Col. L. C. McCabe,** dealt with "The Fuel and Heating Program" and the other paper, by **J. A. Heffernan,** Chief of the Electrical Facilities Unit, Office of Chief of Engineers, was devoted to "Power and Lighting Problems at Army Cantonments."

Buildings of a permanent nature, which are usually of stone and brick, are generally steam heated from a central plant with coal, gas or oil as fuel; whereas the mobilization type of wooden building such as mess halls, hospitals, barracks, etc., are heated by a forced warm-air furnace, the heat being distributed over both floors by ducts.

Boilers of 150 hp and over in central heating plants are fired by mechanical stokers of the various types, and in a few of the larger plants pulverized coal has been employed. More than 70 per cent of the oil-burning units have now been converted to coal. Draft gages are provided for all boilers of 100 hp and over and units of 300 hp and over are equipped with either a steam-flow meter, or a steam flow-air flow meter, CO_2 recorder, flue-gas temperature recorder, etc. Automatic draft controls are authorized for all boilers of 150 hp and larger.

Cooperating with the Combustion Service of the Army Engineers are a number of advisory civilian bodies such as Bituminous Coal Research Inc. and Anthracite Industries Inc. whose engineers instruct army personnel in combustion problems. The Bureau of Mines has also acted in an advisory capacity, particularly with reference to feedwater treatment.

The Army will use between 8 and 9 million tons of coal in the next fiscal year for steam heating, space heating, water heating and cooking.

The Army budget for the coming year provides for a consumption of over 2,750,000,000 kwhr of which the greater part will be purchased from utilities over lines operating at voltages ranging from 2300 to 132,000 volts. Some 18,000 miles of line must be maintained and the total maximum demand will approximate 550,000 kw, which is equivalent to that of Boston and Washington metropolitan areas combined.

Interior lighting represents over 50 per cent of the connected load at the average army cantonment, connected power over 25 per cent, electric cooking about 15 per cent and outdoor protective lighting 2 per cent. Inside lighting intensities of about one watt per sq ft are provided as compared with 0.2 watt in 1918.

Plant Protection

Discussing "War Time Protection of the Power Plant," by **Lt. Col. A. G. Coulson** explained that the primary responsibility rests with the owners and operators. Employees must be trained to act promptly and properly in the event of fire, explosion or other emergency and vital areas must be restricted to those persons having duties requiring their presence there.

An effective system of plant protection must cover the power-generating station, substation and switching centers, overhead and underground transmission lines, and warehouses and storage yards. One of the most vulnerable parts of the generating station is the operating gallery which must be restricted and locked at all times. Other vital parts are the lubricating and fuel oil supply which might easily be destroyed by fire or contaminated by abrasive material, and the condensing water intake into which a floating bomb might be in-

troduced. The coal conveyor system should also be closely guarded.

Fire is one of the most effective weapons used by the saboteur as equipment can be disabled for a long time, if not destroyed, and evidence is likely to be covered up. A bomb will damage material or equipment in the immediate vicinity but a fire may be widespread.

Oil storage rooms should be kept locked and fire protection facilities installed. Manhole covers on water conduits leading to the pumps should be securely fastened; also, crib houses should be kept locked and be a point of patrol for the guards. The coal conveyor system should be protected from destruction by maintaining the housing as free as possible from dust, and there should be an adequate water supply and adequate hose in the upper bunker area of the generating station. Also arrangements should be made for isolating portions of the coal pile which may be on fire. Dykes should be placed around oil tanks to permit prompt draining in case of fire.

The use of dogs to supplement guards and flood lighting around power plants and switching centers is particularly advantageous because their keen senses will detect an intruder much more readily than a guard working alone. A well-trained dog can be worked with two men, that is, sixteen hours a day. They are especially valuable in isolated sections where hydroelectric plants are usually located. While power lines are easiest to strike at and hardest to protect, they are also the easiest part of the system to repair and place back in service, if a trained repair crew is kept in readiness and spare tower parts are kept on hand.

At the same time it is most important to prevent accidents that may damage essential equipment or injure trained personnel. **Major R. W. Applegate,** Chief of the Industrial Safety Branch, Sixth Service Command, discussed this problem with particular reference to utilities and described the safety inspection and consultation service that has been set up by the Army for this purpose.

Other Papers

"Guideposts on the High-Pressure Road" was the title of a paper by **D. B. Jones** of Hall Laboratories which dealt broadly with water problems causing outages and increased maintenance with high-pressure boilers. The formation of various scales and deposits was reviewed and the function of phosphate treatment under various conditions was discussed, as were also oxygen corrosion and metal cracking.

Among the group of electrical papers was one on "War Time Industrial Applications of Electrical Equipment," by **D. L. Beeman** of the General Electric Company which dealt with the design of power distribution systems, demand factors in industrial plants, service requirements, selection of voltages, circuit arrangements, substations, etc. Another was on "Resonant Grounding for Long-Distance Power Transmission Systems" by **W. A. Lewis,** Director of the School of Electrical Engineering, Cornell University; and a third, by **T. J. Higgins,** of the Illinois Institute of Technology, dealt with "Design of Direct-Current and Low-Frequency Bus Systems."

In the field of diesel power there was a paper on "Effect of Fuel Composition on Disposition in Diesel Engines" by **L. E. Hebl** and **L. W. Griffith,** both of the Shell Oil Company. This included test data showing the wide difference in piston deposits with different oils, all possessing conventional physical properties; also, other tests showing the effect of lubricating oil additions on deposits from the fuel.

A paper by **J. R. Fellows** of the University of Illinois discussed the "Possibilities and Limitations of Small Hand-Fired Furnaces" which covered banking methods and the control of smoke when burning bituminous coal, also the features of a proposed new design of furnace.

At the Friday luncheon meeting **F. W. Hollister,** Chief Electrical Engineer of Sargent & Lundy, discussed conservation in the design of power stations. He pointed out that whereas in the past it had been the usual practice to balance economics against conservative engineering, at present conservation is being given greater weight than economics, because of the materials situation. Moreover, indications are that there will be few 100 per cent reversions to previous practices.

Logistics

At the banquet on Thursday evening, the principal address was by **Col. James L. Walsh** whose topic was "Logistics—The Science of Survival." The speaker emphasized that the old definition of logistics, as that brand of military science concerned with the details of supply and transport of an army in the field, is now obsolete inasmuch as war is now a struggle for survival between the entire populations of large groups of nations. Moreover, total war has erased all distinction not only between combatants and non-combatants but also between things needed to supply armies and those needed to maintain the civilian populations. Therefore, under existing conditions, if we accept strategy as the *plan* and tactics as the *method*, logistics is the *means* of getting the right amount of things to the right places at the right time, not merely to supply and transport an army in the field, but also to insure the continued existance of the populations.

By next June we must be converting man-hours of labor and raw materials into munitions of war at a rate equivalent to building one Panama Canal per day throughout the following year.

Although the United Nations have a superiority in population over the Axis Powers of 2.9 to 1, in land area of 14 to 1 and in potential fighting man-power of 5.5 to 1 (including China and the Netherland Indies), yet during the five months following Pearl Harbor, the Japanese alone overran 1,328,000 sq mi in Asia and the Southwest Pacific and brought to their domination some 119 million human beings—all because of the time factor involved.

An ocean supply line of 12,000 miles is eight times as long as one of 1500 miles, hence to supply identical fighting forces requires eight times as many ships.

Time is the critical and controlling factor in logistics, not statistics which are stationary.

This emphasizes, for example, the importance of dehydrated foods in supplying our overseas forces. By this means it is now possible for one ship to do the work which required six ships a year ago. Not only are the number of cargo ships reduced but also the number of their escorts.

Drying Mineral-Wool Insulating Cement on Turbines by Infrared Lamps

Because of unavailability of the usual flexible glass pads, except for covering the flanges, mineral wool cement was substituted as cylinder insulation. This was applied in layers, the drying of each layer being expedited by infrared radiation before application of the next. The laboratory tests and field experience suggest the employment of infrared drying for other insulation applications.

By W. F. KINNEY

Research Dept., The Detroit Edison Co.

THAT "necessity is the mother of invention" was once more borne out by a recent experience in The Detroit Edison Company when the installation of a 75,000-kw, 900-F turbine generator presented the problem of applying and drying heat-insulating cement on the turbine cylinder. The solution that was ultimately arrived at can best be covered by discussing the nature of the problem, the features of the laboratory investigation and the details of the procedure that was followed in the field.

Preliminary Considerations

When it was learned that flexible glass pads would not be available for insulating the turbine cylinder because of restrictions placed upon the extensive use of glass cloth for non-military purposes, several alternate types of insulation were considered. Of these, mineral-wool insulating cement was being used more and more frequently for such service. Use of this material on portions of the turbine that would not be disturbed during maintenance work, in conjunction with removable glass pads, which were available only in limited quantities, on the horizontal flange, appeared to be most satisfactory from all practical standpoints. However, as judged by previous experience with this material, it immediately became apparent that a problem would be encountered in satisfactorily drying the layers of insulating cement.

Discussion of the drying problem at that time with insulation and turbine manufacturers and with operators and construction engineers in other power plants revealed that virtually no applications of this kind had been completed on large turbines, such as the one in question; that in most cases these had been made on turbines of less than 25,000-kw capacity, and that a number of different techniques had been followed. A review of this information revealed the following:

a. Some installations were made on cold surfaces and were air-dried at room temperature; some were made on surfaces at about 200 F; and one was applied and then dried during the turbine starting cycle.

b. The elapsed time for applying and drying the cement varied from eight days to about one month.

c. The turning gear was used in some cases where steam was admitted; it was not used in another case where steam was admitted, and was not used in the case where the insulation was dried during the starting cycle.

d. When steam was used, the condensate was usually drained through the turbine drains and a partial vacuum and circulating water in the condenser were generally considered to be essential.

e. Only slight cracking of the cement was encountered in any case.

f. Asbestos cement surfacing was used in a few cases; no surfacing was used in several other cases and a planished steel casing was furnished in all cases.

These findings pointed to one general conclusion, namely, that it is a tedious and lengthy process to dry heat-insulating cement unless the equipment upon which it is applied is in operation at a substantial temperature.

Experience gained by us in the past from other types of installation, where cement was applied while the equipment was in operation, was of little value in selecting the drying procedure that should be followed when cement is to be applied on cold surfaces many weeks before the equipment is to go into service. It is generally acknowledged that in the latter case, the length of time (two to four weeks) required for drying a $1^1/_2$ to 2-in. layer by natural evaporation makes it advisable to use some means for accelerating the drying. The only procedure that had been proposed, and which appeared to be practical, was to admit low-pressure saturated steam through a temporary line to the turbine to heat the cylinder. However, it was realized that when insulating cement is applied on a hot surface, the first layer dries fairly rapidly but thereby becomes an effective heat barrier so that the outer layers must then depend virtually upon natural evaporation and so will dry very slowly. It is not until the equipment has been in operation for several days at full temperature that cement becomes dry throughout.

Before a decision was reached regarding the proposed procedure, and in view of the uncertainties involved, a

laboratory investigation was initiated for the purpose of finding a suitable means for accelerating the drying of mineral-wool heat-insulating cement.

Laboratory Investigations

Laboratory tests were conducted in which samples of cement were dried by using: (*a*) heat applied internally to a test casing with the surface of the cement exposed to air at room temperature, which simulated the heating of a turbine cylinder by means of steam; (*b*) heat similarly applied internally to a test casing in conjunction with external air at about 160 F, which provided the additional factor of warm circulating air; (*c*) poultry netting reinforcing in the cement used as an internal electric resistance-heating element; (*d*) infrared radiation from lamps directed toward the outside surface of the cement.

It was found that with the use of infrared lamps a $1^1/_2$ to 2-in. layer of cement could be dried in about 16 hr whereas the other procedures required 48 hr or more. It was also found that, when the heat was applied internally to the test casing, such as that provided when low-pressure saturated steam is admitted to a turbine, the claim that a 48-hr drying period would suffice was substantiated only for the first layer of cement. Each subsequent layer required at least twice that length of time to dry, owing to the temperature gradient through the inner layer of dried cement which rendered the application of internal heat less effective for drying the outer layers. Further, it was found that no substantial reduction in drying time resulted from the use of a commercial wetting agent, even though the water required for a workable mix was thereby reduced from about 2 to 1.3 lb per lb of dry cement.

Selection of a Field Procedure

Although the proposal had been made to the Company that low-pressure saturated steam be admitted to the turbine to aid in drying the cement, when the time arrived to make preparations for insulating the turbine, certain important auxiliaries, namely, the circulating-water pump, the vacuum pump, the extraction-steam piping and the sealing-steam leakoff lines, had not yet been installed. It was then decided that the admission of steam to the turbine without a partial vacuum in the exhaust casing and without circulating water in the condenser tubes should be avoided. Because several weeks would have elapsed before these conditions could be attained and the degree of drying obtainable by that means was doubtful, and in view of the results of the laboratory tests that had been conducted, it was decided to expedite the application of the insulation by using infrared radiation to accelerate the operation of drying the cement.

Field Procedure

The mineral-wool heat-insulating cement was mixed with only sufficient water to make it easily workable, which in no case exceeded 2 lb of water per pound dry cement. The wet mix was covered with wet burlap and allowed to temper at least four to eight hours and usually overnight. Two insulation mechanics and two helpers required six to eight hours to apply one layer of cement and poultry netting reinforcing on one-half of the turbine. Four portable banks of infrared lamps were assembled. These consisted of 2, 3, 5 and 5 rows per bank, respectively, with eight lamps in each row. Tungsten-filament reflector-type and carbon filament type 250-watt infrared lamps, of which a supply was on hand, were used. Power connections of 35 kw capacity with appropriate fuses and switches were also available in the plant. In addition, a small heating bank of six similar lamps was available for use in various relatively inaccessible locations, such as at piping connections, at the ends of the admission valve casing and in narrow spaces where the larger banks could not be placed. This small bank did not provide so effective

Fig. 1—Arrangement of infrared lamps for drying insulating cement on upper portion of turbine

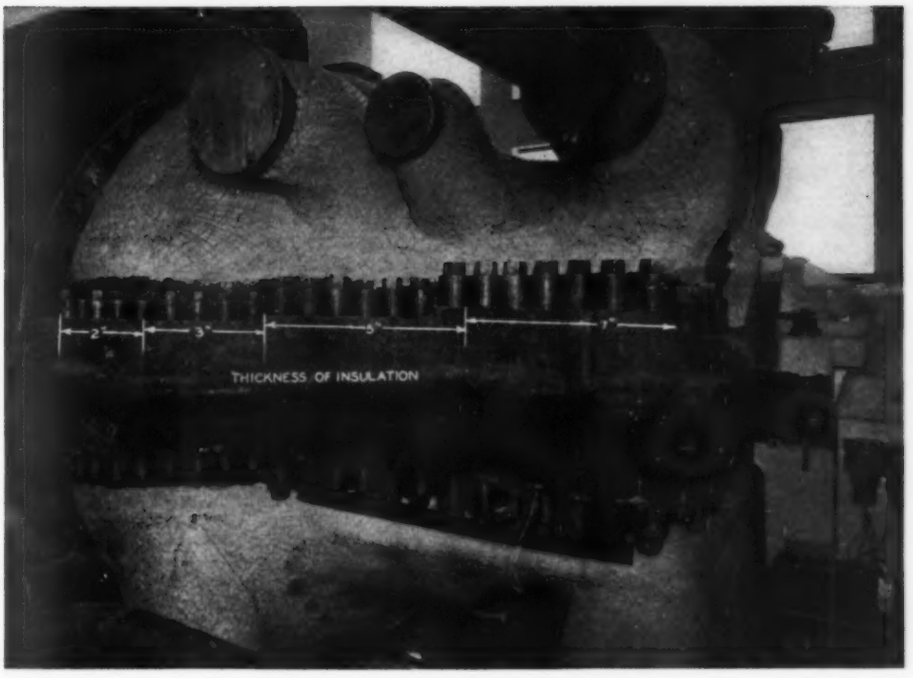


Fig. 2—Final scratched layer of insulating cement; note trough under bolt heads

drying as the larger banks but it materially aided in the drying operations.

The detailed procedure that was followed in insulating this turbine was governed by construction conditions in the field as they existed at the time the work was started. The turbine rotor was in place and the flanges were bolted. No auxiliary piping or structural accessories had yet been installed around the turbine, and the generator rotor had not been delivered.

The steps in the procedure were as follows:

First Week.—Two inches of cement was applied over the entire turbine cylinder. It was then decided to complete the drying of all the layers on the upper half first and then move the drying equipment to the lower half in order to save the time and labor required for moving the heating banks back and forth repeatedly. Therefore, the first layer of cement on the bottom half was allowed to air-dry until the application on the upper half had been completed. In order to hold the heating banks in position over the upper half of the turbine a wooden framework was assembled by placing two 4 × 4-in. ridge poles from the top center of the exhaust flange to the top of the end control-valve guides, forming a horizontal V with its apex on the exhaust flange. Other poles were slanted downward from these ridge poles and cross-braced. As is shown in Fig. 1, three of the infrared heating banks were suspended from this framework, and the fourth, a 5-row bank, was placed vertically in front of the admission valve casing. Approximately 12-in. clearance was allowed between the face of the lamps and the insulation in all cases. The lamps were operated overnight for about 16 to 20 hr. Each day the infrared heating banks were lifted away from the turbine sufficiently to permit the workmen to apply the next layer. Successive $1^1/_2$ to 2-in. layers of cement were applied and dried overnight until the required thickness was attained. This varied from 2 in. at the low-temperature end to 7 in. on the admission-valve casing and high-temperature end. Each layer was reinforced with poultry netting attached to a steel-rod framework that had been welded onto the turbine cylinder to provide appropriately spaced anchor points. These are visible in Fig. 1. The fourth and final layer on the top half of the turbine cylinder was applied on the fourth working day and, in order to insure as thorough drying as possible, the infrared lamps were operated for about 64 hr over the weekend.

Second Week.—The first layer of cement on the bottom half of the turbine cylinder had been air-drying during the first week as mentioned and, although it was still quite moist, it was considered to be sufficiently firm to permit the application of poultry netting reinforcing and additional layers of cement. The heating banks were slid into position under the turbine and rested on piping connections and ledges in the foundation that happened to be handy. No supporting framework for the heating banks was required. Almost immediately after the heating banks were placed in operation at this location, several lamps shattered. It was discovered that water vapor, rising from the cement, condensed on the cold surface of some of the flange bolt heads and dripped onto the hot lamps. A metal trough, which is visible in Fig. 2, was rigged under those bolt heads in order to catch the condensation and prevent a recurrence of this trouble. The lamps were operated overnight for 16 hr to dry the second layer.

After the third layer had been applied on the bottom half, the lamps were operated for about 40 hr in order to obtain as complete drying as possible. The work was ahead of schedule and some concern was felt regarding the first layer because it had been only air-dried. The fourth and final layer on the bottom half was installed on the fourth elapsed working day of this week and again advantage was taken of the week-end period to continue the drying. The final, scratch-roughened layer of insulating cement is illustrated in Fig. 2, which also indi-

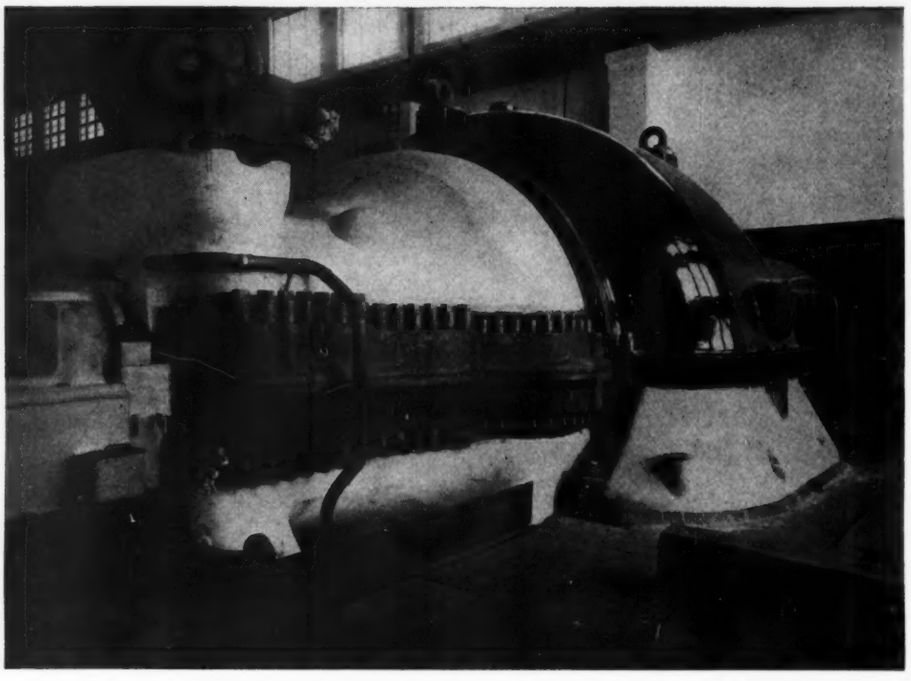


Fig. 3—Asbestos-finishing cement and canvas applied over insulating cement

cates the thickness of insulating cement that was applied on each section of the turbine cylinder.

THIRD WEEK. Asbestos finishing cement about 1/4 in. thick was applied, troweled to a smooth finish, and air-dried. A jacket of 6-oz. canvas was then pasted on. The appearance of the turbine at that time is shown in Fig. 3. Finally, tailored glass turbine insulating pads were installed on the horizontal casing flange and on the high-temperature pipe flanges. The pads were laced on with stainless steel wires that had been fastened to the turbine cylinder and allowed to protrude through the cement when it was applied. Inasmuch as two layers of pads were required on the high-temperature end, the edges of the inner pad were folded over the bolt heads and tucked down behind them; the outer pad was then extended well over this area and overlapped the edge of the insulating cement by at least 6 in., in order to minimize heat losses through these joints. This type of construction is expected to be quite effective.

The completed installation is shown in Fig. 4. The planished steel casing will be installed before the turbine is placed in service.

Observations

As a result of the experience gained in this installation, several precautions and improvements in technique can be suggested for consideration on future installations. These are:

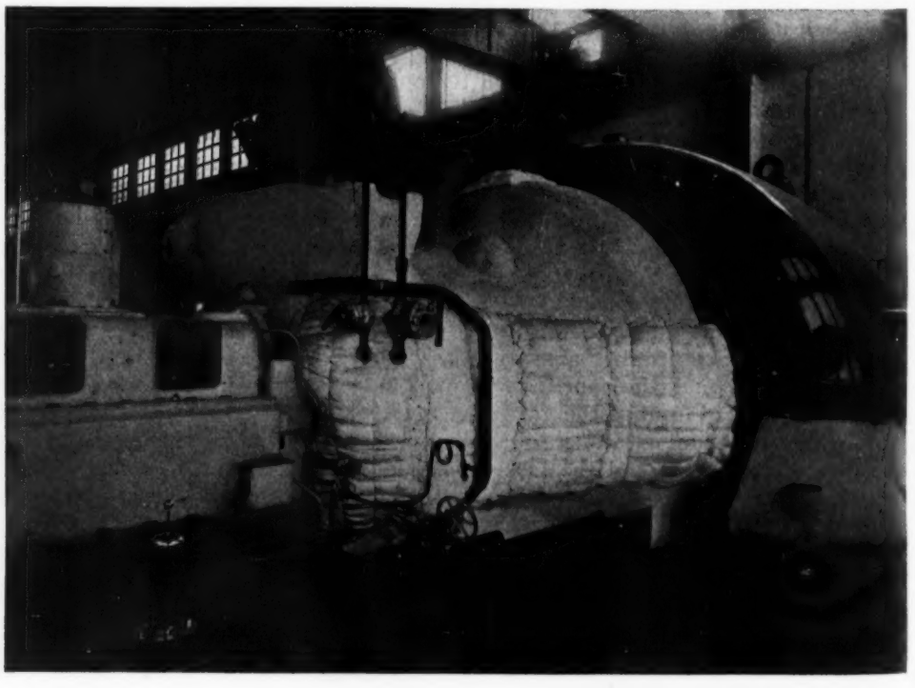


Fig. 4—Completed installation before putting planished steel casing in place. Glass insulating pads cover the flanges

1. If the insulation work can be scheduled well in advance, the most practicable procedure appears to be as follows: Apply the successive layers of insulating cement on both parts of the turbine cylinder while they are readily accessible on the floor prior to installing them. Allow whatever spaces in the cement may be necessary for slings, bolt heads, etc. The infrared heating banks can then be easily placed on the floor, and so arranged as to obtain the most effective coverage of the insulated surfaces. In this way, no conflict with other construction work is likely to occur and the application of the cement and use of the infrared banks would be greatly simplified.

2. On a turbine cylinder that has already been closed, the use of infrared heating banks should not unduly complicate the application of the heat insulation if proper preparations are made. It is advisable in this event to schedule the construction work that must be carried out simultaneously in such order that there will be as little interference as possible. Accordingly, the installation of certain accessories, piping and auxiliary structures around the turbine should be deferred so as not to obstruct space above and below the turbine that is required for properly placing the heating banks to obtain the most effective heat distribution.

3. An intensity of infrared radiation of about 400 watts per square foot of surface was found to be satisfactory; the consumption during the total drying time was about 6500 kwhr.

4. It is advisable to equip the individual heating banks with sufficiently long leads so that the electrical connections to the energy source will not have to be broken each time the banks are slid from beneath the turbine.

5. The use of troughs under the flange bolts should be emphasized in order to prevent dripping of condensation onto the lamps, which causes breakage.

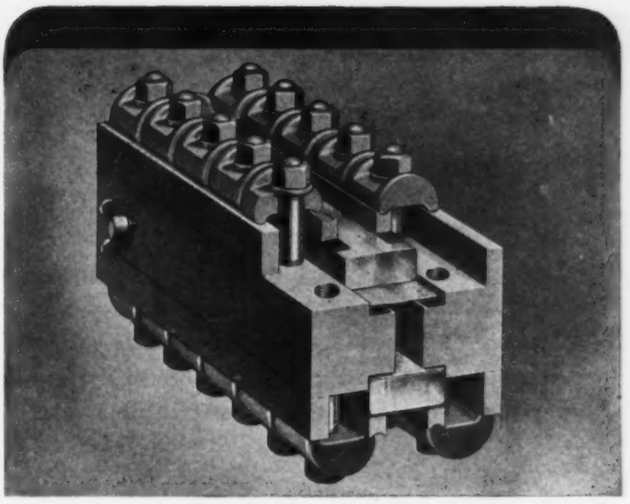
6. In any event, whether the insulation is applied before or after the turbine cylinder is installed in position, the use of a canvas hood, similar to a tent, thrown over the infrared heating banks and the turbine cylinder, should contribute to the effectiveness of the drying procedure and utilize much of the heat that is otherwise dissipated from the surface.

7. The outside surface of the insulating cement should be so shaped as to allow ample clearance for removing bolts and piping during maintenance work without its being necessary to cut away an excessive amount of cement.

Summary

As far as is known, this was the first installation of its kind where infrared radiation has been used to accelerate the drying of heat-insulating cement. The problem was unique and much was learned from the actual experience in the field that will serve as a guide in possible future installations. The findings are considered to pertain to all kinds of insulating cement composed essentially of rock-wool, slag wool or glass wool.

As a further result of this experience, it is believed that infrared drying would also be applicable for expediting installations of mineral-wool insulating cement and asbestos-finishing cements on boiler walls, ducts, pipe bends, fittings, valve bodies, heaters, etc. This would be particularly true in the case of maintenance work when only a limited time is available.



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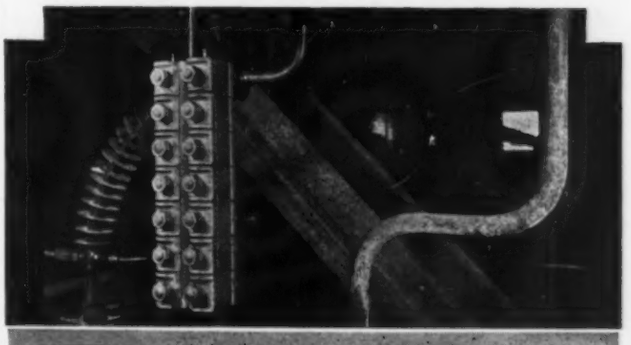

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Selection of Lead Wires for Base-Metal THERMOCOUPLES

In view of the present difficulty in procuring the usual lead wires for thermocouples, substitute materials often become necessary. The relationships of these various materials and combination are discussed and certain adjustments indicated.

By PHILIP DAVIDSON
Raymond Pulverizer Division,
Combustion Engineering Company

IN AND around a power plant or drying system there are numerous points where the temperature is most easily measured or indicated by base-metal thermocouples, in conjunction with indicating or recording instruments. In the past it has been easy to buy special lead wires and, as these have been plentiful, many of us have forgotten the fundamentals necessary to adapt their instruments should copper or iron wire have to be substituted.

. For temperatures encountered in such applications, the couples usually consist of wires of one of the following combinations:

Couple	*Lead Wire*
Chromel–Alumel	Copper–Constantan
Iron–Constantan	Iron–Constantan
Copper–Constantan	Copper–Constantan

Chromel, or the positive element of the first couple, is an alloy containing about 90 per cent nickel and 10 per cent chromium; alumel contains around 94 per cent nickel, 2 per cent aluminum, 2 per cent manganese and 1 per cent silicon, while constantan contains about 60 per cent copper and 40 per cent nickel. In these fields the great majority of the couples are of chromel–alumel, which is recommended for continuous service for temperatures up to 2000 F.

Relationship of Common Elements

The chart, Fig. 1, shows the approximate relationship of the common elements or alloys used in making thermocouples versus platinum with the cold junction at 0 C. The emf produced at the cold junction by joining any two of these elements and heating the couple so formed may be easily estimated by measuring the distance between the lines. The curves show that above the cold junction temperature (in this case 0 C) chromel is positive to the metals shown and becomes negative to them below zero.

It will be appreciated that every time two dissimilar metals are joined together, a couple is formed, which, according to the Peltier effect, causes an impressed emf; and the intensity of this emf across the cold junction is a function of the difference in temperature between the hot couple and the cold junction. If extra couples besides the one in the zone under test are introduced into the system, the emf generated in these couples will be either added to or subtracted from that produced by the main couple, depending upon the metals in the auxiliary couples.

If the chromel and alumel wires (or other couple wires) are extended to the measuring instrument, no new couple is introduced. Provided the wires are of the correct resistance, and that the instrument is in good working order, the correct temperature will be indicated. In normal times such wires are expensive, but under conditions today they are often difficult or impossible to obtain; so it is usual to employ other special wires which will compensate for the new couples so introduced, use one of several methods to compensate in the instrument, or use some method to hold the new couples or cold junction at a definite temperature and adjust the instrument accordingly.

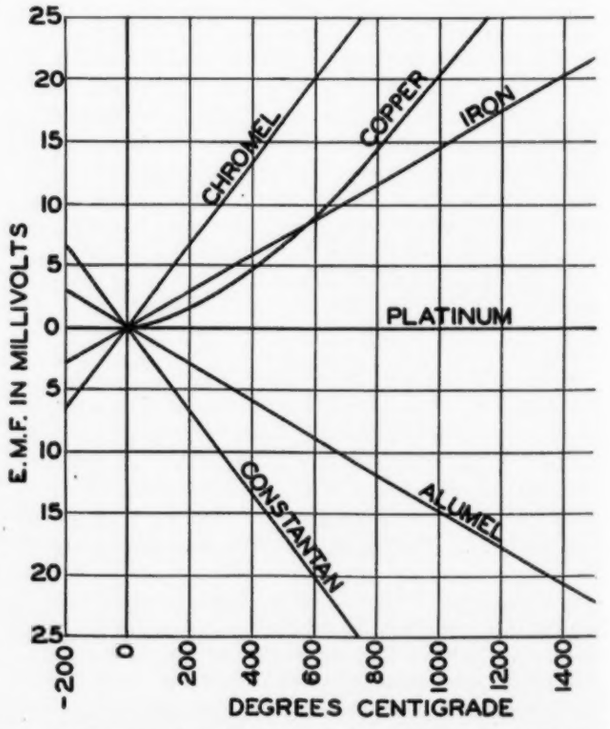

Fig. 1—Comparative thermal-electric power of metals and alloys, with cold junction at zero centigrade

Referring to the chart, it will be seen that if copper–constantan lead wires are used with a chromel–alumel couple (as in Fig. 2) and the cold junction moves over a range from 0 C up to, say, 300 C, or well over the range met in the discussed practice, the emf generated by the cold junction couple of chromel–copper is almost exactly equal, but of opposite sign to that generated by the constantan–alumel couple. Hence, over this range, for all practical purposes, they cancel each other in their effect, and the instrument reads the correct emf generated by the primary chromel–alumel couple.

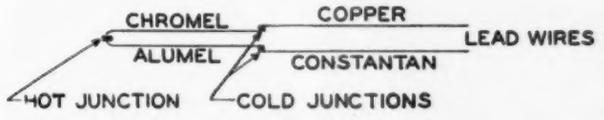

Fig. 2—Copper–constantan leads with chromel–alumel couple

If the cold-junction terminals are at a constant temperature, there is little advantage in using special lead wire with chromel–alumel couples, and either two iron or two copper wires may be used. In this case the recording or indicating instrument will read the hot-junction temperature plus the cold-junction temperature, and it is easy to adjust most instruments to give a true reading of the hot-couple temperature. It may happen, however, that the cold-junction temperature is a variable and still, due to war conditions, it is necessary or desirable to use two copper or two iron lead wires. In this case, two new couples are added to the system, and, as the copper or iron curves (Fig. 1) both lie between the chromel–alumel curves, the emf generated by the addition of these two new couples will exactly equal that which would be indicated by a chromel–alumel couple under the cold-junction conditions.

The reading of the instrument in that case will then be increased by an increment exactly equal to the cold-junction temperature. It therefore follows that if the cold-junction temperature is known, two copper or two iron leads may be used in place of special leads, and the instrument readings just increased or decreased by the cold-junction temperature. Very often, even though the "cold" temperature varies over quite a range, this variation is small when compared to the temperature being measured, and may be ignored.

Instrument Resistance Important if Accuracy Is Desired

With a millivolt-meter type of instrument, which covers the majority in use, the total resistance of the instrument plus that of the thermocouple and leads is of utmost importance if reasonable accuracy is to be obtained. The resistance of the lead wires, of course, is not of such great importance when using an instrument having an internal resistance of the order of 600 ohms, as one having a resistance of the order of 10 ohms. With many commercial instruments, the internal resistance is approximately 585 ohms, and the manufacturer recommends they be used only with special "calibrated" leads and makes it an important point that nothing be added or cut off these lead wires. Investigation will show that the wires as supplied have a resistance of 15 ohms, and that, inasmuch as ordinary 14-gage lead wire has a resistance of the order of 0.06 ohms per foot, it can readily be seen that the 15-ohm resistance is obtained by adding a small diameter wire with high resistance in series with one of the leads.

On the other hand, should it be necessary to extend or cut the length of the leads, in general, it is only necessary to cut or add to the leads (if adding, of course, use the same metal as the lead wire) and then adjust the small high resistance wire so that the total resistance is again 15 ohms.

Naturally, if the lead wires themselves, say 50 ft long, have a resistance of 3 ohms, and the resistance wire in series has 12-ohm resistance, quite a length of wire may be added or cut off without seriously affecting the accuracy of the instrument, and no adjustment need be made to the high resistance wire. The small resistance wire may be made of any metal, as it is only inserted in one lead wire and, of course, the couples formed with this and the lead wire oppose each other and have no effect on the instrument reading.

If copper or iron lead wires are used, they should be adjusted in like manner to have the same resistance as the wires they are replacing, or, in a new installation, of such resistance as to balance with the instrument being used.

In potentiometer types of instruments, no current flows during the observation, so the resistance of the lead wires is immaterial.

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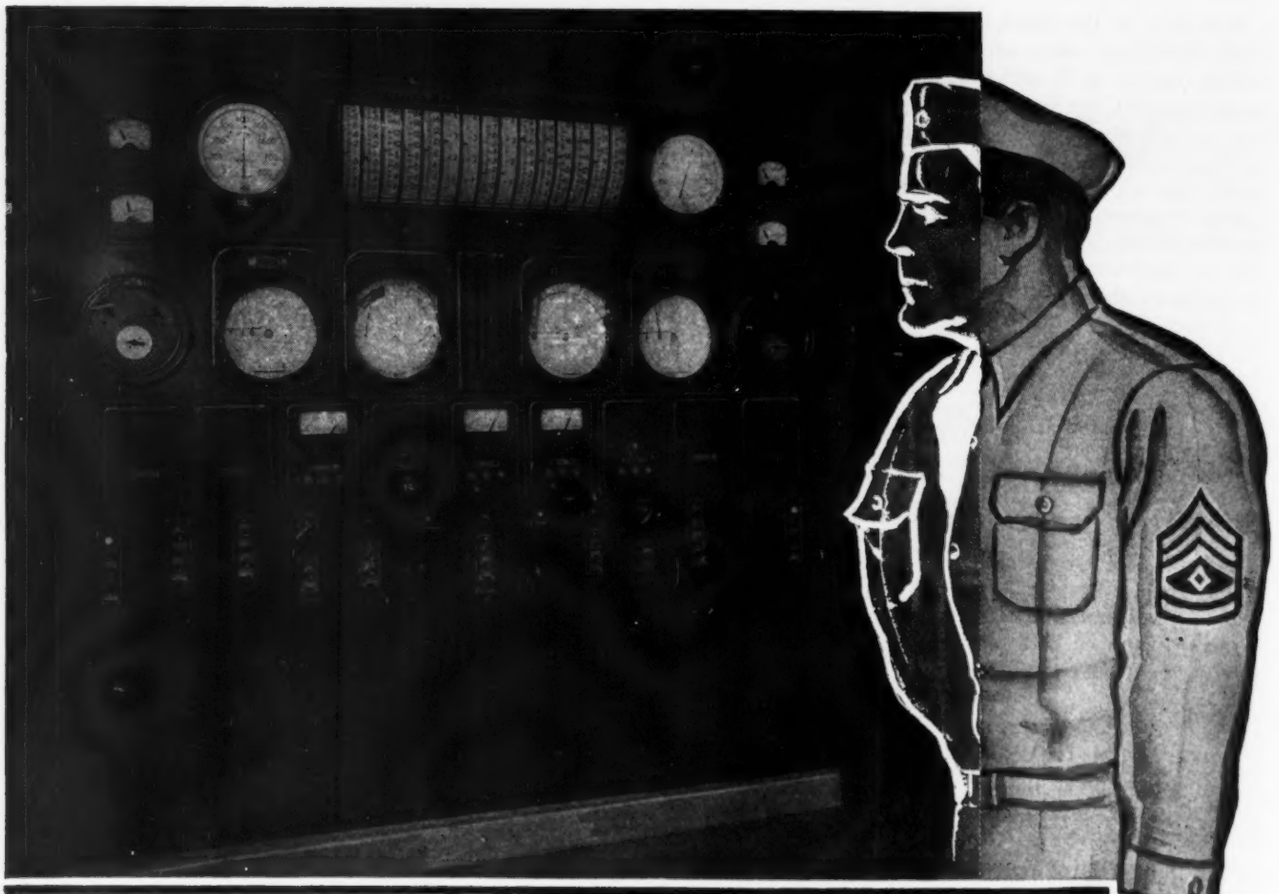

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Operation of Hot-Process Softener at 50 Lb Gage Improves Performance and Saves Chemicals

By C. E. JOOS and FRANK KEMMER

Cochrane Corporation

This installation, with a capacity of 28,000 gph, is designed for 50-lb gage pressure and 298 F, and is believed to be the first and only hot-process softener in service operating under such high pressure and temperature conditions. Saving in both lime and soda ash is thereby effected. The treatment is controlled from analysis of the raw water.

IN THE precipitation type of water softener the reactions by which the hardness constituents of the raw water are removed can generally be one or more of the following:

$$(1)\quad Ca^{++} + CO_3^{=} \leftrightarrows CaCO_3$$

$$(2)\quad Mg^{++} + 2(OH)^{-} \leftrightarrows Mg(OH)_2$$

$$(3)\quad 3(Ca^{++}) + 2(PO_4^{-}) \leftrightarrows Ca_3(PO_4)_2$$

The completeness of each reaction depends upon the solubility of the precipitate formed and upon the provision of an excess of the precipitating ion; that is, carbonate, hydroxide or phosphate.

The solubility of the precipitated hardness decreases and the rates of reaction rapidly increase as the temperature at which the reactions occur is increased from 32 F to 300 F, the practical temperature limits. For this reason, the present-day design of the precipitation type of water softener tends toward the highest practicable temperature that is comformable to the heat balance of the plant. The higher efficiency in the utilization of chemicals and the lower blowdown rates resulting from the lower alkalinities and hardness obtained at high temperatures make such temperatures economically desirable. This has resulted in the gradual supplanting of cold-process softening by higher temperature softening in the preparation of boiler feedwater.

The conventional hot-process water softener receives exhaust steam at approximately 1 to 5 lb above atmospheric pressure, the water being heated to around 210 to 227 F. Operation in this temperature range with an excess sodium carbonate content of 25 ppm results in a reduction of hardness to about 20 to 25 ppm. In general, for each increase of one unit in excess sodium carbonate, the hardness is decreased by one-half unit. Thus, an increase in excess sodium carbonate of 10 ppm would result in a reduction in hardness of 5 ppm. Most of the hot-process water softeners now in service operate at low steam pressures, although there are a number which are designed for operation at 15 to 20 lb gage.

First 50-Lb 298-F Installation

Until very recently, a pressure of 20 lb gage was generally considered the upper limit of design, but about two years ago a unit operating at 30 lb gage and 274 F was placed in service. More recently an installation operating at 50 lb gage and 298 F was installed and is giving exceptional results. It is believed that this is the first and only hot-process water softener in service operating at this pressure. The high operating temperature has resulted in a high degree of hardness reduction and in economy of chemicals.

The installation, illustrated by Fig. 1, has a softening

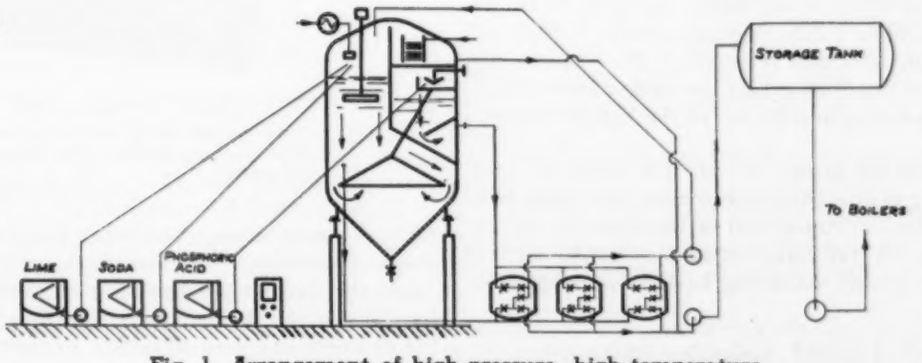

Fig. 1 Arrangement of high-pressure, high-temperature softener system

capacity of 28,000 gph of raw water and a capacity to heat and deaerate condensate at the rate of 16,000 gph. Softening is carried out in two stages. In the first stage the water is given a treatment of lime and soda ash. It is next decanted to a second compartment where it is deaerated and then treated with phosphoric acid[1] to reduce

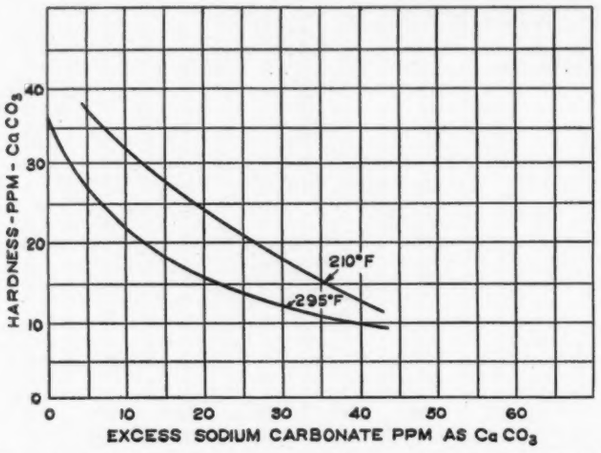

Fig. 2. Hardness vs. excess sodium carbonate for 295 F compared with 210 F

the hardness and alkalinity remaining after the lime-soda-ash process. The final effluent is filtered, combined with the condensate, and used as boiler feed without further treatment. There are three chemical feeds, one for each reagent, lime, soda ash and phosphoric acid.

The water delivered from the second stage, has consistently shown zero hardness by the soap test, or approximately $^1/_2$ ppm by gravimetric analysis. The reduction of hardness is exceptional, not only in the first stage, but also in the second, and it is quite apparent that a high operating temperature is a distinct advantage.

Higher Temperature Reduces Residual Hardness

Analyses of the water after treatment by lime and soda ash in the first stage have indicated that the residual hardness is less than that obtained at lower pressures with a corresponding excess of sodium carbonate. In Fig. 2 the residual hardness and excess sodium carbonate based on data obtained from this installation operating at 295 F and the corresponding values based on data from another installation operating at approximately 210 F are compared. The effect of the higher temperature on the reduction of residual hardness is appreciable. Since the excess of sodium carbonate required at 295 F is less than that required at 210 F to obtain the same residual hardness, there is a saving in soda ash at the higher temperature.

In addition to the saving in soda ash, there is a considerable saving in lime from high-temperature operation. Lime is used for the conversion of bicarbonates to carbonate and for the precipitation of magnesium salts as magnesium hydroxide according to the following reactions:

$$(4)\quad 2(HCO_3^-) + Ca(OH)_2 \rightleftarrows CaCO_3 + 2H_2O + CO_3^=$$

$$(5)\quad Mg^{++} + Ca(OH)_2 \rightleftarrows Mg(OH)_2 + Ca^{++}$$

[1] "Phosphoric Acid—a New Reagent for Use with Hot-Process Softeners," C. E. Joos, COMBUSTION, September, 1942.

At elevated temperatures, bicarbonate can be broken down to carbonate without the use of lime, according to the following reaction:

$$(6)\quad 2(HCO_3^-) \rightleftarrows CO_3^= + H_2O + CO_2$$

This reaction proceeds to a greater degree of completeness as the temperature is increased and as improved methods are devised for the continual removal of the CO_2 gas liberated. At low temperatures, around 210 F the conversion by heat alone is almost negligible, while at high temperatures, around 295 F, approximately 40 per cent of the bicarbonate in the raw water is converted to carbonate by heat, without requiring lime treatment.

If it were possible to operate a precipitation type of water softener at a temperature above 300 F, it would be possible to convert all of the raw water bicarbonate to carbonate by heat alone. This occurs in boilers, where the reaction can proceed to completion because the bubbling of steam through the boiler water in the process of steam generation continually removes the CO_2 formed. After the bicarbonate has been converted to carbonate by this process, the carbonate is broken down to hydroxide to a certain extent according to the reaction:

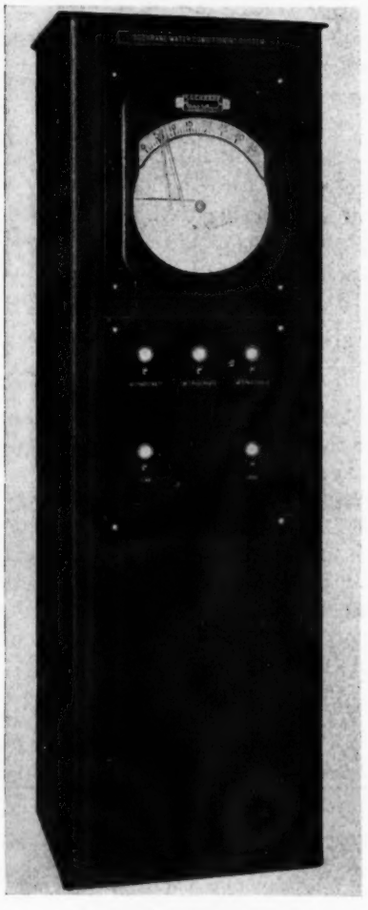

Fig. 3 Control panel

One pen records the rate of flow and the other the temperature of the water from the softener.

$$(7)^2\quad CO_3^= + H_2O \rightleftarrows 2(OH^-) + CO_2$$

[2] See "Conversion of Sodium Carbonate to Caustic Soda Within Steam Boilers," C. E. Joos, *Power*, Nov. 12, 1929.

Controlling Treatment from Analysis of the Raw Water

The method of chemical control incorporated in this high-temperature installation is of interest. The raw water is taken from a small creek, approximately one mile from the mouth of a large river, and is passed through a clarification plant where the suspended matter is removed by a coagulant, principally to meet the requirements of other plant processes. The water delivered to the hot-process softener for treatment is taken from this preparation tank. Its hardness averages approximately 190 ppm, expressed as calcium carbonate, of which about 20 per cent is non-carbonate hardness and 35 per cent is magnesium hardness.

Because of the nearness of the water source to the river, which has a composition decidedly different from that of the creek, the total hardness varies from about 130 to 230 pp, and the non-carbonate hardness varies approximately from 10 to 30 ppm. In rainy weather the water rises in the creek and the alkalinity and the hardness drop; during dry weather most of the creek water comes from the river. These variations in the chemical composition of the water may be frequent and quite sudden.

In the operation of hot-process water softeners, it is customary to regulate treatment according to the character of the effluent. However, it is quite evident that with a long period of retention in the sedimentation tank, combined with rapid changes in the character of the supply, this method is not satisfactory if the characteristics of the effluent are to be maintained within narrow limits. Therefore, the treatment is regulated in accordance with frequent determinations of the hardness and alkalinity of the raw water. The magnesium hardness is assumed to be 35 per cent of the total, which ratio is found to agree fairly accurately with a number of analyses. The use of individual proportioning equipments for the several reagents makes this method convenient, as, in order to make the required change in the amount of lime, soda ash or phosphoric acid being fed into the softener, it is necessary only to turn the corresponding knob on a control panel. The panel board used is of the type illustrated in Fig. 3, which shows a flowmeter and controls for individual reagents.

Combines Economy in Chemicals and Adaptability to Heat Balance

The fact that the sedimentation type of water softener can be operated at pressures up to that corresponding to the 300 F limitation imposed by the A.S.M.E. Code for Unfired Pressure Vessels, makes the hot-process water softener more desirable from the standpoints of economy in chemical treatment and of adaptability to the heat balance of the plant as a whole. A high-pressure softener can be conveniently controlled either by frequent analyses of the effluent, the method recommended for a water of constant characteristics, or by a schedule of frequent analyses of the raw water with subsequent corrections of treatment, the method recommended for waters of varying characteristics. Experience gained from the operation of this high-temperature installation will add to available knowledge on the subject of hot-process softener operation.

Prevention of Fuel Waste*

By J. F. Barkley†

VARIOUS surveys have shown that combustion efficiency in the use of much of our coal output is too low and that effective effort would improve the use of at least 300,000,000 tons of coal per year 10 to 15 per cent. Fuel is one of the bulkiest items of transportation. The consumption of less fuel will relieve the mines as well as transportation facilities, an exceedingly important consideration at present. It is estimated that 25,000 coal miners working one year would be needed to mine the equivalent of the above indicated saving in coal, which would fill about 670,000 railroad cars.

Waste of fuel at this time gives definite help to our enemies, and all efforts should be made to prevent it. This country must conserve to the utmost its fuel resources—its basic war power.

It is suggested to fuel users that the following recommendations be checked at their plants to determine to what extent they are being followed:

1. PREPARATION OF FUEL—Keep the larger and smaller sizes of solid fuels well mixed, if possible. Keep undesirable water out of the fuel.
2. EQUIPMENT—Clean, oil and repair fuel-burning equipment, and maintain all automatic equipment and controls in proper adjustment. Keep boiler-room instruments properly calibrated and in good working order.
3. COMBUSTION—Use no more air than is necessary to prevent too much unburned fuel, including smoke, from going out the stack. Study the flaming of the fire and its color. Watch for dark smokiness. Note the fuel-bed conditions as to thickness, holes, caking, clinkering and hot flying particles. Take the temperature of the flue gases, and watch the carbon dioxide if instruments are available. Prevent undesirable unburned fuel in the refuse; reburn siftings and fly ash high in carbon.
4. DRAFTS—Keep the draft or suction in the furnace and the wind-box pressure as low as possible. Maintain dampers and damper bearings in good condition.
5. USE OF BOILERS—Arrange the number of boilers on the line to use the least fuel, avoiding sustained high overloads as much as possible.
6. BOILERS—Stop all undesirable air leaks in the boiler setting around headers, doors, peepholes, shells, drums and soot blowers. Keep all heat-transfer surfaces clean on both sides. Keep furnace brickwork and baffles in good repair, with baffles free from soot and fly-ash piles.
7. BLOWING DOWN—Blow down boilers as little as possible.
8. LEAKS AND INSULATION—Keep equipment and piping free from steam and water leaks. Insulate all possible hot surfaces to lower heat losses.

NOTE: Devise fuel-saving schemes peculiar to your boiler plant, including possible changes in equipment.

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† Chief, Division of Solid Fuels Utilization for War, Bureau of Mines.

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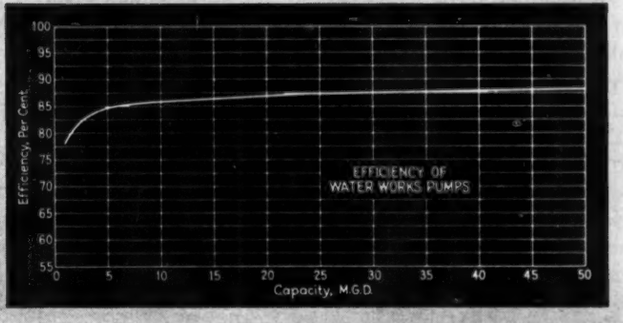
Unit No. 4 in the acceptance test on January 22, 1927, showed a wire-to-water efficiency of 82.7 per cent and, when tested again on January 20, 1933, an efficiency of 83.9 per cent.



Efficiencies attainable with various capacities at heads between 125 and 225 ft.

Similarly, Unit No. 5 on the acceptance test on March 3, 1927 showed 83.3 per cent efficiency and, when tested again on January 31, 1933, it showed 83.9 per cent.

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For further particulars and other instances, ask for Publication P-3225.

DE LAVAL STEAM TURBINE CO. . . TRENTON, N. J.

Rubber from Steam and Alcohol

By JOHN R. CARLSON, Steam Engineer,
Westinghouse Electric & Manufacturing Co.

This plant is laid out to produce enough butadiene and styrene to make 100,000 tons of Buna S. rubber per year. Operation is scheduled for next summer and the process steam requirements will be more than a million pounds per hour, for which four large boilers are being installed. Power will be supplied by a single non-condensing turbine-generator. The selection of steam conditions, heat balance and unit sizes is reviewed.

A NEW industry is rapidly being formed in the United States. It is an industry to produce synthetic rubber on a large scale. Contrary to general opinion, and, even though large-scale manufacture of synthetic rubber is in its infancy, the chemical processes are not new. As far back as World War I several million pounds of synthetic rubber were manufactured in Europe. Even in the United States, where a plentiful supply of natural rubber was available, considerable research was conducted on synthetics and manufacture undertaken principally to produce those products that had certain physical properties superior to natural rubber for specific uses where cost was secondary.

After the loss of the sources of natural rubber, the problem was not one of discovering a chemical process to make synthetic rubber, but rather one of abruptly changing or building new plants to manufacture synthetic rubber in large quantities. New plants could not be built overnight, as much new equipment is required for efficient processing. For example, to supply only the water for such a plant requires huge pumps, large enough to supply the water required by a city twice as big as Pittsburgh. Large boilers and turbine-generators are needed to produce the necessary steam and power to manufacture the raw materials.

In an eastern state, the Koppers Company is building a new plant to produce butadiene and styrene, the principal and essential materials for Buna S. rubber. The butadiene will be made from alcohol and the styrene from coal and alcohol. About 80,000 lb of steam are required to produce enough raw materials to make 2000 lb of rubber. As this new plant is being laid out to produce enough butadiene and styrene to make 100,000 tons of rubber per year the amount of steam needed expressed in pounds per hour is almost astronomical.

Gibbs & Hill, Inc., of New York is designing and constructing the steam plant to serve the new rubber plant. Four boilers are required to supply the vast quantity of steam needed.[1] Operation of the steam plant is scheduled for the middle of 1943.

Steam for the production of butadiene and styrene is needed at pressures varying from 725 to 75 lb. The greatest amount is used to provide heat for the production of butadiene, the requirements for styrene being about one-fourth of that for butadiene. In addition to heating, large quantities of steam are needed to drive steam-driven compressors. While the heating requirements could largely be satisfied by supplying steam at approximately 75 lb pressure, more effective use would be obtained by supplying it to the butadiene plant at a pressure high enough to be used first for driving compressors. By arranging the compressor engines to exhaust at 75 lb gage, both mechanical power and low-level heat are provided. Flexibility and additional steam needs for the styrene and butadiene plants are obtained through reducing valves.

In addition to the large amounts of mechanical power used, considerable electrical power is needed to run the plant and effect the proper heat balance. It was estimated that the electrical power consumption would be about $\frac{1}{2}$ kwhr per pound of product produced, or approximately 16,000 kw. Studies showed that economies could be obtained by generating steam at some high pressure, such as 600, 800 or 1200 lb, and expanding it through a steam-turbine generator unit. This turbine would be of the non-condensing type arranged to exhaust at a pressure high enough to serve the butadiene and styrene plants. In this way steam would perform a triple duty: (1) by driving the turbine-generator to provide electrical energy; (2) by driving the compressors to provide refrigeration; and (3) by providing heat for process.

Selection of Steam Pressure

Selection of the initial steam pressure was given a great deal of attention as there were numerous factors influencing its choice. Obviously, the higher the boiler pressure, the greater the output of by-product power from the turbine-generator unit. However, other factors indicated that a moderate pressure should be adopted, particularly when it was realized that at times the boiler plant might have to operate with 80 per cent makeup as the steam sent to process would be lost. At best, only one-third of the condensate would be recoverable and even then there was possibility of its being contaminated with oil or acids. Introducing raw water in large percentages into a high-pressure boiler usually requires very complete treatment of the feedwater or the use of evaporators and a closed system.

With the closed system high-pressure steam is generated in the boilers and expanded through a non-condensing turbine. This steam is condensed in an evaporator, and returned to the boiler as pure condensate. In this way, all raw water is excluded from the boiler. Raw water is used in the evaporator to condensate the high-pressure steam, but in condensing the high-pressure steam it is vaporized. It is the vaporized raw water or steam that is sent to process. As the evaporator operates at a much lower steam pressure it functions successfully with 100 per cent makeup. Such closed cycles are expensive and wasteful of critical materials because of the large evaporators required and reduced amount of by-product power obtainable.

More careful attention to treatment of feedwater has made it possible to dispense with the expensive evaporators and to build high-pressure steam plants capable of operating with 100 per cent makeup. Several such plants have been in operation for a number of years with satisfactory results. These plants are less expensive than those employing the closed system and are becoming more generally used. Chemical treatment of the feedwater was the method selected for the new steam-generating plant in this case. Because of this and the size and importance of the plant it was felt that conservatism should be exercised in the selection of the steam pressure.

Other factors influencing the choice of steam temperatures and pressures was the desire to use a minimum of critical raw materials. Instead of using highly alloyed steels for certain parts they could be made from the more easily obtainable low-carbon steels.

While boiler problems influenced the selection of steam pressure, consideration was also given to a pressure that would permit the use of a standard design of turbine. High steam pressures are the accepted standard today and practically all turbines are basically designed for efficient operation with high steam pressure. However, the requirements for the process steam—more than 1,000,000 lb per hr—are so large it was found that a surplus of electrical power would be generated even with low boiler pressures. But low steam pressures require abnormally large diameter pipes and steam passages and are to be avoided whenever possible. Even with the steam conditions finally selected—725 lb gage and 750 F—the steam chest and throttle valve are equivalent in size to that required by a 150,000-kw condensing turbine.

[1] A section through one of these boilers, a 350,000-lb per hr C-E forced-circulation unit was shown in the December 1942 issue of COMBUSTION —*Editor.*

A continuous supply of steam, to the butadiene plant, is assured by reducing valve stations with desuperheaters installed in parallel with the main turbine which permit 725-lb steam to pass directly to the exhaust.

Feed-Heating System

To improve the thermal efficiency and to increase the power output of the steam plant the feed to the boiler is heated in a simple two-stage system consisting of a shell-and-tube heater and a deaerating heater. The steam for these heaters is obtained from the blowdown from the boiler, the exhaust of the main turbine and the exhaust from the turbine-driven power house auxiliaries. Introducing large quantities of feedwater continuously into the boiler would soon build up the concentration of soluble salts in the drums and excessive concentration of salts and impurities in the boiler water would, in turn, be likely to cause carry-over in the steam. These impurities would be deposited on the turbine blading and cause a reduction in capacity and efficiency. Therefore, the boiler concentrations are to be kept to reasonable values by blowing down.

Heat in the blowdown is conserved by flashing part of the hot blowdown into steam in a high-pressure flash tank (at the same pressure as the exhaust of the turbine-generator unit). This vapor is led to the high-pressure feedwater heater and is used to partially heat the boiler feed. The remaining blowdown is led to a low-pressure flash tank where additional water is flashed into steam and is admitted to the deaerating heater. The remainder of the blowdown, containing a high concentration of impurities, is passed through a water-to-water heat exchanger where it gives up more heat to the incoming 60 F boiler feed. The blowdown is finally cooled to a temperature of 80 F before being discharged to the sewer.

The boiler feed after first passing through the blowdown heat exchanger is heated to approximately 240 F in the deaerating heater. Here it is thoroughly deaerated before entering the boiler feed pumps. A storage tank is incorporated in the deaerator to allow for variations in steam flow and water flow. From the boiler feed pumps the feed is passed through a drain cooler. In the drain cooler heat in the condensate leaving the high-pressure heater is given up to the boiler feedwater. From the drain cooler the feed passes into the high-pressure heater which raises the temperature to 363 F before entering the boiler.

7600 Hp in Steam Auxiliaries

As the heat in the boiler blowdown is far from being sufficient to heat the boiler feedwater, large quantities of steam must be obtained from other sources. The additional steam required by the deaerator is obtained from the exhaust of the power house auxiliary drives. The boiler feed pumps, the induced-draft fans, forced-draft fans and circulating pump (for the forced-circulation boiler) are all driven by steam turbines. These auxiliaries, fourteen in number, required approximately 7600 hp of general purpose turbines. These auxiliary turbines could be designed, either to take steam from the main header, or from the exhaust of the main turbine-generator unit. Header pressure steam was selected for the auxiliary drives because the exhaust pressure resulted in surplus steam for the deaerator. By using 725-lb steam a very close balance is obtained and only under certain conditions of operation is it necessary to make up for any deficiency. Furthermore, taking the steam for the auxiliaries directly from the main header kept the capacity of the main turbine-generator unit of practical size. Supplying the steam-driven auxiliaries from the exhaust of the main turbine would have meant a very material increase in steam flow through the main turbine with a consequent increase in size of turbine parts.

All of the steam from the high-pressure flash tank is supplied to the high-pressure heater but it is only a fraction of the amount needed to heat the boiler feedwater. The deficiency is made up by taking steam directly from the exhaust of the turbine-generator unit.

The steam pressure supplying the process and high-pressure heater is maintained by means of an exhaust-pressure regulator on the turbine. This device regulates the steam flow through the turbine so as to maintain the desired pressure. The steam supply to the deaerator is maintained by reducing valves which automatically open to maintain the pressure if the steam flow from the boiler room auxiliaries is too low.

Power Tie with Utility

Inasmuch as the output of the turbine-generator is greater than the requirements of the synthetic rubber plant, a surplus of electrical energy is available. Arrangements were made with the local utility to absorb and distribute the energy over its lines. In addition, the frequency of the power generated is maintained by the utility's generating units. As the normal function of the new turbine is to supply steam to the synthetic rubber plant, its controls are set to respond to exhaust pressure changes rather than speed or load changes. The generation of electrical energy is purely a by-product.

In case of an interruption of the tie-line between the utility and the turbine generator unit, the exhaust-pressure regulator can be rendered inoperative and the turbine speed governor will take over and maintain the frequency.

The new steam plant has only one turbine-generator unit. No reserve capacity will be installed. This is possible only because of the cooperation of the local utility which will supply power through an interconnection should the turbine-generator be shut down. Should such a condition occur steam will be supplied to the butadiene plant through a combination reducing valve and desuperheating station. With this arrangement the use of critical materials and manufacturing facilities is kept to a minimum.

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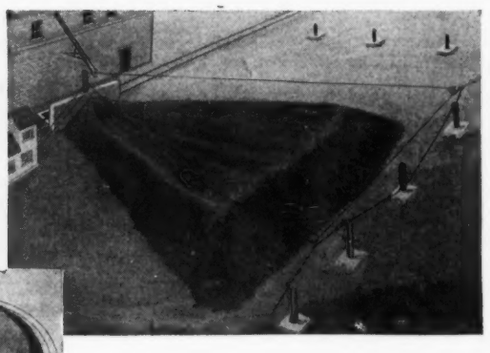

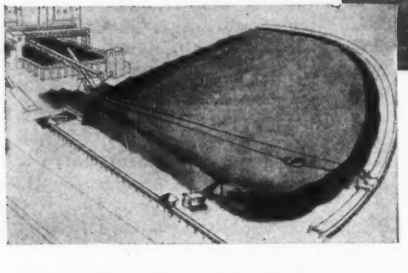

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Proposed Canons of Ethics for Engineers

This report* has been prepared by the joint committee appointed by the boards of the constituent societies of the Engineers Council for Professional Development, for the purpose of formulating a code of ethics suitable for general adoption by engineering societies and other organizations in the engineering field. The report has been approved by the Council and referred to the constituent organizations for adoption, comments, or recommendations regarding items to be omitted or added.

Foreword

JUSTICE, courtesy, honesty and sincerity, associated with mutual interest between men, make the foundation of ethics. Ethics should be more than passive observance of a code of "Don'ts" in the life of an engineer. They should be recognized as dynamic principles guiding his conduct and his way of life.

The principles are briefly set forth in what follows.

Professional Life and Employment

1. The engineer will avoid conduct and practices likely to discredit the honor and dignity of the engineering profession.

2. He will cooperate in building up the engineering profession by interchanging information and experience with other engineers and students and by contributing to the work of engineering societies, schools and the scientific and engineering press, without disclosing confidential matter.

3. He will present clearly the consequences to be expected from the deviations proposed if his engineering judgment is overruled by nontechnical authority in cases where he is responsible for the technical adequacy of engineering work.

4. He will endeavor to protect the engineering profession and all reputable engineers from misrepresentation and misunderstanding.

5. He will take care that credit for engineering is attributed to those who, in so far as his knowledge goes, are the real authors of the work.

6. He will maintain the principle that unduly low compensation for engineering employment tends toward inferior and unreliable results and is to the disadvantage of his profession.

7. He will not advertise his work or merits in a self-laudatory manner or in a way injurious to the dignity of his profession.

Relations with Other Engineers

8. The engineer will not intentionally, directly or indirectly, injure the reputation or business of another engineer.

9. He will not try to supplant another engineer in a particular employment after becoming aware that decision to employ the other has been reached.

10. He will not compete with another engineer on the basis of charges for work by underbidding through reducing his normal fees after he has been informed of the charges named by the other.

11. He will not use personally the advantages of a salaried position to compete unfairly with another engineer.

12. He will not knowingly review the work of another engineer, for the latter's client or employer, without the other engineer's knowledge unless the latter's connection with the work has terminated.

13. He will not knowingly become associated in responsibility for engineering work with engineers who do not conform to ethical practices.

Relations with Clients and Employers

14. The engineer will endeavor, in so far as it is possible, to secure justice between his client or employer and the contractor when dealing with contracts.

15. He will act in professional matters for each client or employer as a faithful agent or trustee.

16. He will not accept compensation, financial or otherwise, from more than one interested party for the same service, or for services pertaining to the same work, without the consent of all interested parties.

17. He will not, without the full knowledge and consent of his client or employer, have an interest in any business which may bias his judgment regarding engineering work for which he is employed or which he may be called upon to perform, or have an interest in a business which may compete with the business of his client or employer.

18. He will not be financially interested in the bids as a contractor on competitive work for which he is employed as an engineer unless he has the consent of his client or employer.

19. He will not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with his client or employer.

20. He will make his status clearly understood to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions, apparatus or any other thing in

* Reprinted from E.C.P.D. Tenth Annual Report, 1942.

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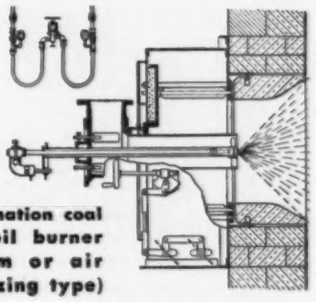
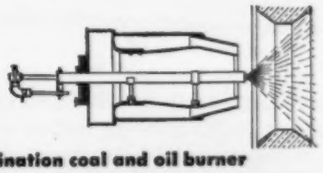


Combination coal and oil burner (Steam or air atomizing type)



Combination coal and oil burner (Mechanical atomizing type)

Enco Burners

which he may have a financial interest.

21. He will regard it his duty to guard against dangerous elements in apparatus, structures or plant, or dangerous conditions of operation therein, and upon observing such conditions in work with which he is associated, he will call them to the attention of his client or employer. If dangerous conditions persist with his knowledge, he is not fully relieved of his responsibilities.

22. He will, when he is a public officer, recognize his limitations and, under such conditions, retain and cooperate with other engineering experts and specialists whenever such cooperation may be serviceable.

Relations with the Public

23. The engineer will interest himself in the public welfare and be ready to apply his special knowledge, skill and training for the benefit of mankind.

24. He will assist public officials and others in attaining a fair and correct general understanding of engineering matters, extend the public knowledge of engineering and discourage untrue, unfair and exaggerated statements regarding engineering.

25. He will recognize the fact that meetings of engineering societies and the engineering press provide the proper forum for technical discussions and criticisms, and also that clear statements of facts relating to engineering enterprises are often of value to the public when they are prepared for laymen's understanding and released by competent authority through the public press.

26. He will not issue *ex parte* statements, criticisms or arguments on matters connected with public policy which are inspired or paid for by private interests unless he indicates on whose behalf he is making the statements.

27. He will not express publicly an opinion on an engineering subject without being informed as to the facts relating thereto.

28. He will express no opinion which is not founded on adequate knowledge and honest conviction while he is serving as a witness before a court, commission or other tribunal.

29. He will not lend his name to any questionable enterprise or engage in any occupation contrary to law.

30. He will make provisions for safety of life and health of employees and of the public who may be affected by the work for which he is responsible.

31. He will carry on his work in a spirit of fairness and loyalty to associates, subordinates and employees, fidelity to the public needs and devotion to high ideals of courtesy and personal honor.

Dr. Charles F. Scott, in a minority report, stressed the need for a concise Code which, when added to application forms for State Registration, could be used as a basis for action in case of violation. A Code, substantially like that of the Connecticut Registration Board, was proposed as an alternative.

A.S.M.E Spring Meeting at Davenport, Ia.

The American Society of Mechanical Engineers will hold its 1943 Spring Meeting at the Hotel Blackhawk in Davenport, Iowa, from April 26 to 28. The impact of the war is again apparent in the selection of the subjects scheduled for presentation and discussion which include sessions on Industrial Training and the War Effort, Aviation, Manpower and Ordnance Practice. Among the topics of particular interest to engineers in the power plant field are the following:

Monday, April 26

"Operation of Industrial Power Plants Under Wartime Conditions," by G. H. Suhs, Sorg Paper Co., Middletown, Ohio.

Colored Movies of Fuel Burning Operation and Maintenance During Wartime, shown by Otto de Lorenzi, Combustion Engineering Co., New York.

"Caustic Washing of Turbine Blades Under Load," by W. L. Webb and R. G. Call, American Gas & Electric Co.

Tuesday, April 27

"Steam-Air Jets for Producing Furnace Turbulence," by R. B. Engdahl, Battelle Memorial Institute, Columbus, Ohio.

"Direct-Fired High-Temperature Carbon-Steel Air Heaters," by R. M. Rush, Dravo Corporation, Pittsburgh, Pa.

"Theory of the Expansion of Boiler and Condenser Tube Joints Through Rolling," by A. Nadai, Westinghouse Research Laboratory, E. Pittsburgh, Pa.

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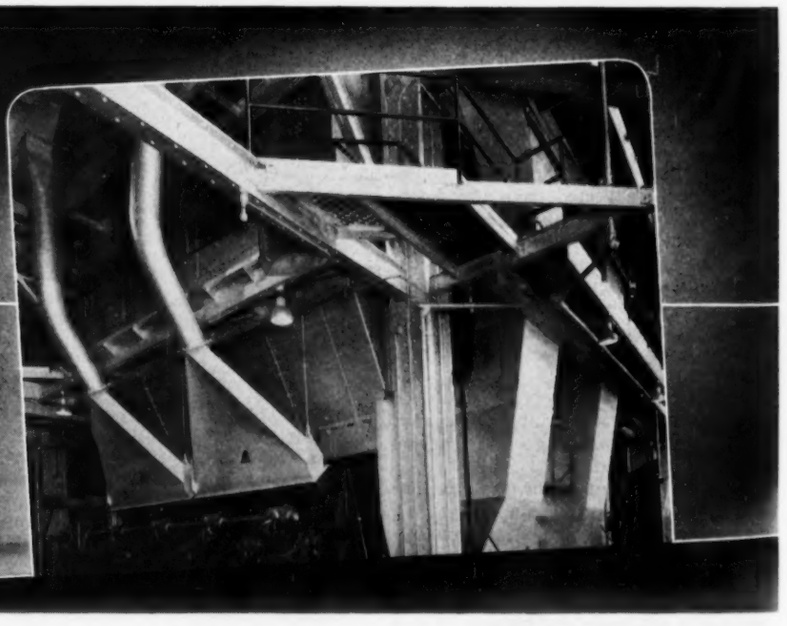

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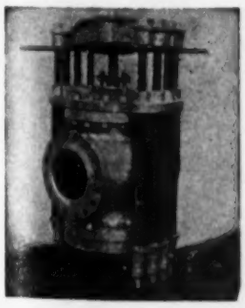

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Right — No. 110 Exhaust Relief Valve for condenser protection service.

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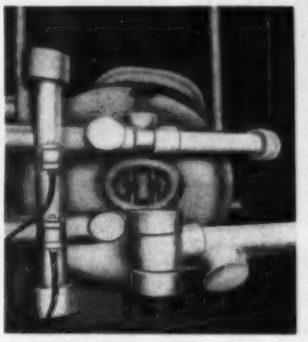

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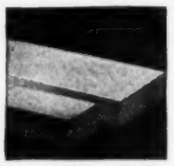

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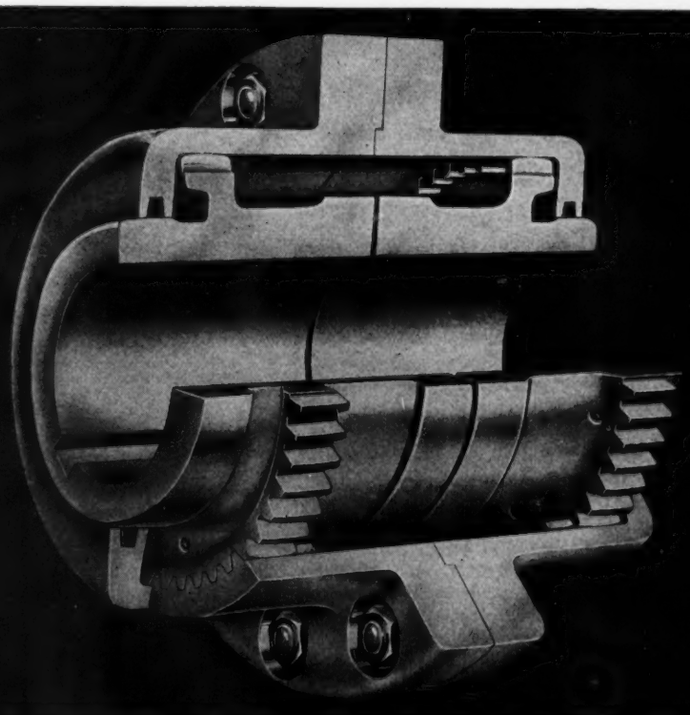

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REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Economy Loading of Power Plants and Electric Systems

By Max J. Steinberg and Theodore H. Smith

The material presented in this book has been developed to meet the requirements of load dispatchers, system operators and operators of generating station equipment to whom the allocation of load to power plants and to the equipment within them is an ever-present problem of producing electric energy at the lowest possible cost consistent with the obligation of maintaining continuity of service.

Although the "incremental rate theory" is now generally accepted to obtain economy loading, many misconceptions still exist in respect to its practicability and the methods of applying it. For this reason, the authors have been prompted to follow the following pattern: (1) The derivation of the mathematical conditions for obtaining maximum overall efficiency by the loading of equipment in parallel operation; (2) the application of incremental rates for the academic solution of load-division problems; (3) limitations in the application of the incremental rate theory; and (4) the practical solution of load-division problems for the purpose of eliminating laborious computations without materially affecting the precision of results.

The book is divided in six comprehensive chapters, dealing with Theoretical Background, Load Division in the Boiler Room, Load Division in the Turbine Room, Station Performance, System Load Division and Miscellaneous Applications. The text is supplemented with 41 tables, 94 charts and four photographic halftones showing the loading slide rule with various strip charts. The book, which comprises 203 pages, size $5^3/_4 \times 9$, is indexed and includes a bibliography. Price $3.50.

Industrial Radiology (Second Edition)

By Ancel St. John and Herbert R. Isenburger

The engineer or layman who desires to obtain some knowledge of the practical aspects of industrial radiology, and also of the basic theories involved, will find this book an excellent aid. It furnishes authoritative information in readable form. It presents not only the general principles governing the production and the use of X-rays and gamma rays, but also the special technique suitable for important classes of materials used by industry. It represents the actual experience of the authors in the development and use of routine methods for rapid and economical inspection in large-scale commercial operations.

The book contains 21 chapters covering all practical aspects of industrial radiography and fluoroscopy which are abundantly illustrated. Most of the curves and tables have been adapted from data available in the literature, supplemented by private records. For those who may wish to study the subject more extensively, a bibliography comprising 1314 references has been appended.

The book has 298 pages, size $5^3/_4 \times 9$, and is bound in dark blue cloth. Price $4.00.

Marine Electric Power

By Captain Q. B. Newman

This book explains the essential principles of electrical engineering to the layman or high school student without recourse to a knowledge of advanced mathematics and physics. It is written in an easy conversational style and covers the more elementary aspects of electrical equipment and operation. The text includes 28 chapters which are illustrated with 160 diagrams and charts. The book is indexed and contains 238 pages, size $4^3/_4 \times 7^3/_8$. Price $2.50.

Practical Marine Diesel Engineering

By Louis R. Ford

The unparalleled expansion of the U. S. Maritime Commission's shipbuilding program is reflected in the increased demand for technical books in the marine field, and it is not surprising that the third edition (1941) of *Practical Marine Diesel Engineering* has been rapidly exhausted.

The present (fourth) edition of this book has required little change in the body of the text as the Diesels featured are those used in the Maritime Commission's standard motorships. Considerable space is devoted to their construction, operation and maintenance. Space is also given to descriptions of machinery arrangements in these ships, and the indirect drive system adopted by the Commission is thoroughly explained.

In the present edition two new chapters have been added: one covering Deck Machinery, and the other, Electrical Machinery. These are designed to acquaint the engineer with the principal types of equipment outside the engine room that are serviced by the engine room crew. Latest developments in new types of equipment associated with motorship propulsion, such as electric couplings, hydraulic couplings, superchargers, etc., are discussed to give the engineer a general working knowledge of their operation. The book contains 32 chapters including one on Shipyard Repairs, and a revised chapter on Obtaining a License as a Motorship Engineer.

The book contains hundreds of illustrations and comprises 642 pages, size $6 \times 9^1/_8$, bound in bright green buckram. Price $6.00.

Questions and Answers for Marine Engineers, Books III, IV, V and VI

Compiled by Captain H. C. Dinger, U.S.N. (Retired)

The preceding volumes in this series, *Book I—Boilers*, and *Book II—Engines*, recently reviewed on this page, have now been supplemented by four more volumes: *Book III—Auxiliaries; Book IV—Applications of Steam and Heat in Producing Power; Book V—Powering Fuel Economy, Propulsion, Propellers and Shafting;* and *Book VI—Water Treatment, Corrosion and Safety Rules.*

In *Book III* the questions deal with auxiliary equipment such as pumps, condensers, feedwater and fuel oil heaters, air pumps and injectors, compressors, evaporators and other miscellaneous items. *Book IV* deals with questions pertaining to efficiency in evaporation and condensation, and other matters in connection with heat engine systems. *Book V*, besides covering the subjects included in the title, includes a chapter on Tonnage and Hull Characteristics, and also one on Special Methods of Propulsion and Control. *Book VI*, besides covering Water Treatment, Corrosion, Fire and Safety Rules also includes chapters on: Lubrication and Oil; Examinations for Licensed Engineer Officers; and Specimen Examination Questions.

These volumes are of a handy pocket size, $5 \times 8^1/_8$. Though sparingly illustrated they are well indexed and admirably fulfill the intention of the author in providing a helpful means of expanding the knowledge of the marine engineer. Bound in paper covers. Price $1.00 each.

Heating, Ventilating, Air Conditioning Guide—1943

American Society of Hearing and Ventilating Engineers

The 21st edition of the *Guide* issued by the American Society of Heating and Ventilating Engineers contains 48 chapters of technical data and general information pertaining to all phases of heating, cooling, ventilating and air conditioning, and related phases of refrigeration.

An important part of the *Guide* is the Revised Catalog Section in which much useful data on equipment have been supplied by manufacturers. The new volume includes 872 pages of technical data; 264 pages of equipment data; and the Roll of Membership of the Society. Bound in a blue cover. Price $5.00 per copy; thumb-indexed copies are available at $5.50.

Obituaries

Charles T. Main, widely known consulting engineer and past president of the American Society of Mechanical Engineers, died in Winchester, Mass., on March 6 at the age of 87. During his long career as a practicing engineer, Mr. Main had been identified with the design of many mill and industrial power plants as well as hydroelectric installations.

John E. Schmeltzer, technical assistant to the Vice Chairman of the U. S. Maritime Commission and a recognized authority on marine engineering, died suddenly on February 24 while en route from Providence to Washington. He was 61 years old.

A. C. Flory, for many years manager of the steam turbine department of the Allis-Chalmers Mfg. Company, died on March 1. He had been in poor health for some months. A graduate of Lehigh University, he joined the Allis-Chalmers organization shortly after finishing school in 1904 and became manager of the steam turbine department in 1919. He was a member of the A.S.M.E. and the Milwaukee Engineering Society.

James T. Machen, Asst. Vice President and Manager of Agencies of The Ric-Wil Company, died suddenly on March 31 while attending a sales meeting in Cleveland. Mr. Machen was born in Laurens, South Carolina, 34 years ago and had been a member of The Ric-Wil Company for 14 years.

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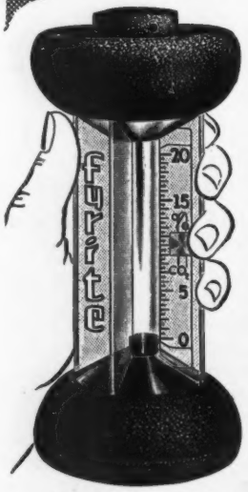

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